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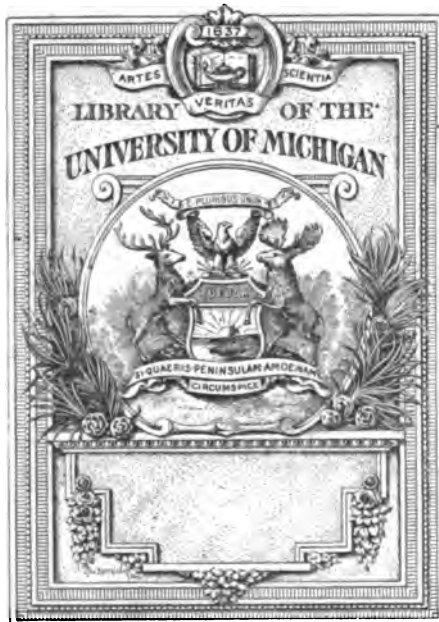
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Agricultural Experiment Station.

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MARCH, 1891.

EXPERIENCES WITH EGG PLANTS.

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BULLETINS OF 1891.

26. Experiences with Egg Plants.

EXPERIENCES WITH EGG PLANTS.

I. GENERAL NOTES OF CULTIVATION.

The egg plant appears to have received little systematic attention, either from gardeners or students.* Yet it is an important and interesting plant and there are indications that it can be considerably modified by treatment. Our own studies of the egg plant began five or six years ago, but three years were consumed in learning how to grow it. During the last two years we have grown all the varieties which we have been able to procure in this country, in France and in Japan.

1. *Culture.* The chief difficulty in growing the egg plant in the north is the shortness of the seasons. It is only by starting plants early and maintaining a vigorous growth that we can succeed in fruiting the large sorts satisfactorily. The plants should be started under glass from the middle of March to the middle of April in a warm house. The chief cause of our failure during our early experience was, the lack of a good forcing house. In the cold and small house at our disposal the plants grew slowly

* Some of the neglect of the egg plant is due to the fact that cooks are not familiar with it. The following recipes for cooking the fruits we have found to be reliable :

1. *Fried.* Cut in slices crosswise not over a half-inch thick and parboil in salt water about fifteen minutes ; then remove, and fry in a hot spider in butter and lard.

2. *Fried.* Cut into slices $\frac{1}{4}$ or $\frac{1}{2}$ inch thick and lay in strong brine for two hours ; then wash *very* thoroughly ; sprinkle with brown sugar, pepper and salt and fry slowly to a dark brown.

3. *Baked.* Cut in two lengthwise, remove the seeds and pulp and fill with dressing made of half teacupful bread crumbs, one teaspoonful butter and salt and pepper to taste ; lay the halves side to side in dripping pan, add a little water and bake nearly an hour.

4. *Fritters.* Pare, cut in thin slices crosswise and soak in salt water for eight or ten hours ; dry on a towel, dip in beaten egg and roll in bread crumbs, then fry slowly in hot butter until the pieces become a rich brown ; serve hot.

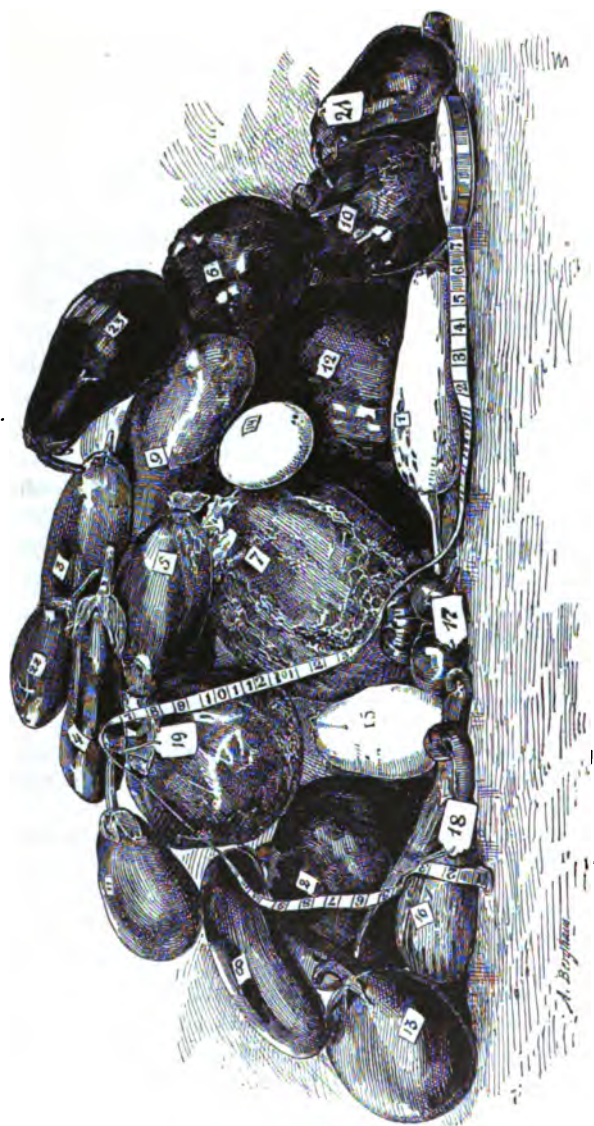


FIG. 1. TYPES OF EGG PLANTS.

1, White Chinese. 2, 13, 19, Black Pekin. 3, 9, Long Purple. 4, 8, Early Long Purple. 5, 11, Early Dwarf Purple. 6, 10, Round Purple. 7, Giant Round Purple. 12, New York. 14, Round White. 15, Long White. 16, Striped or Guadeloup. 17, Ethiopian. 18, Snake. 21, 23, Dwarf Japanese. 22, White Egg.

and when set out of doors they were not of sufficient size and vigor to begin bearing at once. We sow in "flats" or boxes, and when the first true leaves are about a half inch in diameter — which is about a month after the seed is sown — the plants are pricked off into 2-inch pots. As soon as the pots are filled with roots, the plants are shifted into 4-inch pots. We have had in-different success in transplanting into other flats as the plant is more severely checked when placed in the field from the greater injury to the roots. It is imperative that the plants should not become "drawn." The plants are transferred from the 4-inch pots to the garden from the first to the middle of June. The early sorts, as Early Dwarf Purple, are not so seriously injured by a check in growth as the large and late sorts, and they can therefore be handled with less care. These sorts can be started two weeks later than the others and receive but one transplanting. The effects of early and late setting are shown in the following experiment :

Seeds of several varieties were sown March 27 and May 15. On the 7th of September they presented the following differences : Long Purple, Giant, Round Purple and Long White from early sowing were productive, but few or no fruits had formed on the plants from late sowing. Early Long Purple and Round White from the late sowing were fully as productive as those from the early sowing. Early Dwarf Purple gave best results from plants started April 15. This shows that there is little or no gain in productiveness in the small early sorts from very early sowing, while the large sorts profit by it. The Black Pekin, which is one of the large varieties, proved an apparent exception, however. Plants started May 1st gave better results than those started earlier, but neither lot was satisfactory. The unsatisfactory results from the early sowing may have been due to the loss of the first flowers because of the transplanting. Transplanting usually has the effect of keeping plants growing to the detriment of the flowers ; and egg plants which are in bloom when removed to the field are apt to drop the flowers. It is important in the large sorts to induce the first flowers to set. The particular relations of transplanting to fruitfulness are under experiment at the present time.

The best soil for egg plants is a rich sandy loam, — not too light, — which contains an abundance of humus and retains mois-

ture. Manure heavily. We set the large kinds three feet apart each way, although they can be set somewhat closer if land is very valuable. The ground should be thoroughly cultivated throughout the season. We run through our patches lightly with the cultivator at least twice a week.

The worst enemy of the egg plant is the potato beetle, which prefers egg plants to potatoes. The egg plant grows slowly and any injury to the young plant is overcome with difficulty, if at all. If the plants are seriously injured when first set out there will be little use in attempting to fruit them, especially the large kinds. We use Paris green, one pound to 100 gallons of water.

It is rare that all the plants in a large plantation of the common or late varieties mature fruit, and such kinds as Black Pekin, New York and Giant Round Purple rarely mature more than two large fruits to the plant in this latitude, and often only one. The Early Dwarf Purple, Early Long Purple, and other early and medium varieties mature from four to eight fruits without difficulty. The value of any of the late varieties depends very largely upon the uniformity with which all the plants in any lot set and mature fruit. The New York Improved appears to possess this advantage over the old New York (*New York Purple*). The value of continuous and careful selection to this end was illustrated in the behavior of our large plantation of crosses last year, in which a large percentage of the plants were entirely unfruitful, showing that a promiscuous lot of seedlings is likely to be unproductive; and in this case these were crosses between productive parents.

Breeding plants of uniform productiveness is the most important field in egg plant experimentation at present.

2. *Varieties.* The varieties of egg plants, though not numerous, are exceedingly various. They represent wide differences in almost every particular, as habit, pubescence, spininess, color of plant and fruit, size and shape and season of fruit. The very large varieties, as New York Improved and Black Pekin, are most popular in the markets, but some of the earlier and smaller kinds are better. The white varieties find little demand in the markets and there is an impression that they are unwholesome, but they possess no other fault than a hardness of flesh and rind in the case of the small varieties. The White Chinese is as good as any of the purple sorts for table use. The varieties fall readily into the following classification:

I. Plant tall and stout, spiny or spineless; leaves usually large and thick, scurfy, conspicuously angled or lobed; flowers very large; fruit mostly large, spherical or oblong. (*Solanum Melongena* var., *esculentum*.)

A. *Fruit Purple*.



FIG. 2.—*Black Pekin*.

1. **BLACK PEKIN.** (*Ronde de Chine* or *Noire de Pekin*) Vil-morin. Thorburn. Japan. Fig. 2. Nos. 2, 13 and 19, Fig. 1. Plant large and vigorous; stems, petioles and veins deep purple; leaves dark purple above, with a metallic lustre. Fruit large, 6 to 8 inches in diameter, spherical or somewhat compressed, very dark purple or almost black. Very handsome and one of the

most popular varieties for market, but it must be started early. It is entirely distinct from all other varieties — both in habit and fruit.

2. **NEW YORK.** (*New York Purple.*) Thorburn. No. 12, Fig. 1. Plant vigorous and erect; stem and petioles light green, very pubescent; leaves large, spiny on the midrib. Fruit of medium size, spherical or oblong, slightly flattened, dull purple. Not so good as the next.



FIG. 3.—*New York Improved.*

3. **NEW YORK IMPROVED.** Thorburn. Fig. 3. Plants large and vigorous, profusely branching, dark green, the stems, petioles and veins usually purplish on the upper surfaces; leaves very large. Fruit large, eight or nine inches in diameter, short-oblong, uniform and good. Very productive. The best large variety. Fig. 3 is an excellent representation of it. The *New Jersey Improved*, Buist, appears to be the same.

4. **GIANT ROUND PURPLE.** (*Violette ronde très grosse.*) Vil-morin. Fig. 4.* No. 7, Fig. 1. Much like New York Improved,

* Figs. 1, 4, 6, 7 and 9 have been loaned us by the *American Garden*, but they were all made from our own photographs.

but fruit larger — sometimes a foot in diameter — rounder, and somewhat darker colored, and evidently not so productive. It is a type of egg plant which appears to have been selected for size of fruit rather than for uniformity. It includes the "mammoth" varieties offered by American seedsmen.



FIG. 4.—*Giant Round Purple*.

Mammoth Purple, Livingston, we cannot distinguish from it.

5. **ROUND PURPLE.** (*Violette Ronde*). Vilmorin. Thorburn. Fig. 5. Nos. 6 and 10, Fig. 1. Plant medium in size, but vigorous. Fruit small to medium, spherical or oblong, pale violet. Late and usually unproductive. Of no particular merit. Fig. 5 shows one of the best plants.

6. **LONG PURPLE.** (*Violette longue*). Vilmorin, Thorburn. Fig. 6. Nos. 3 and 9, Fig. 1. Plant medium in size, dull green or slightly tinged with purple; leaves medium in size, slightly lobed. Fruit oblong or club-shaped, six to nine inches long and two to three inches in diameter, dark purple. Of excellent quality and fairly productive, but for general culture the next is preferable.

7. **EARLY LONG PURPLE.** (*Violette longue hâtive*). Vilmorin. Henderson. Nos. 4 and 8, Fig. 1. A sub-variety of the last, slightly smaller both in plant and fruit, foliage a little darker, and fruit a little earlier. One of the best varieties.

B. *Fruit white or striped.*



FIG. 5.—*Round Purple*.

8. **WHITE CHINESE.** (*Blanche longue de Chine Long White Chinese.*) Vil-morin. Fig. 7. No. 1, Fig. 1. Plant of medium size, light green throughout; leaves medium in size with small lobes or only undulate margins. Fruit long, club-shaped for curved, abrupt-

ly rounded at the apex, six to ten inches long and two to four inches in diameter, becoming yellowish at full maturity. A handsome variety of good quality and fairly productive. Should be started early.

9. **LONG WHITE.** Thorburn. No. 15, Fig. 1. Plant very like the preceding variety. Fruit rather small, oblong, greenish-white, indifferent in appearance. Fairly productive, but not so good as the preceding.

10. **STRIPED, or GUADELOUP.** Thorburn. Fig. 8. No. 16, Fig. 1. Plant like White Chinese and Long White. Fruit oblong or ovoid, twice as long as broad — usually three to five inches long — white with pink or purple longitudinal stripes. Very prolific. The color varies between different plants. Valuable only for ornament.

11. **ROUND WHITE.** Thorburn. Fig 9. No. 14, Fig. 1. Plant light green, the stems and petioles smooth and shining underneath the slight covering of scurf. Fruit small — rarely four inches long — egg-shaped, white and becoming yellowish at full maturity. Very prolific, but scarcely edible as the flesh is very hard and the skin tough. Vilmorin's cut of this variety has been used to illustrate the "Nest Egg Gourd" in an American catalogue.

12. **WHITE EGG.** Figs. 10 and 16. No. 22, Fig. 1. Very

small, scarcely a foot high. Fruit very small, an inch or two in diameter, pure white, very prolific. Curious and interesting and valuable for ornament. We received seed of this from Japan, and have given it the above name. It has probably attracted the most attention of any variety we have grown.

II. Plant medium to tall; leaves large, angled, scarcely downy; fruit very long and slender.

13. SNAKE.
— (Var. *serpentinum*). No. 18, Fig. 1. Fruit a foot or more long and less than an inch in diameter, curling at the end, purple. It is very late and we have not been able to ripen the fruit. We obtained it from Japan.

III. Plant small, weak and spreading, spineless; leaves small, thin, smooth or nearly so, rounded and more or less undulate; flowers small and long-peduncled; fruit medium to small, pear-shaped, purple. (Var. *depressum*).

14. EARLY DWARF PURPLE. (*Violette naine très hâtive*). Thorburn. Vilmorin. Japan. Figs. 11 and 17. Nos. 5 and 11,



FIG. 6. — *Long Purple*.

in Fig. 1. Plant low ; stems and petioles dark purple, slightly pubescent ; leaves small — the blades 4 to 6 inches long — dark green with a tinge of purple. Fruit four or five inches long, pyriform, very dark purple, often maturing six to eight fruits to the plant. Probably the most valuable variety for the home garden, but too small to sell in competition with the common sorts. Fig. 11, which shows about half a plant is an admirable illustration of the habit and character of fruit.

This is our favorite variety for eating. The fruits are small



FIG. 7.—*White Chinese*.

enough to accommodate themselves to the size of the family, while the late kinds are too large for one and often for two or even three meals. The variety is very early, productive, and the most easily grown of any egg plant. Seeds can be started as late as May 1st with good results, if they are grown vigorously. It readily overcomes any check, as may be seen from this experiment : At the last transplanting of this variety

last spring the flat containing a few extra plants was placed out of doors against the side of a building, where it remained until our egg plants were set in the field. Once or twice frost cut tender plants near them, and they were crowded and were often



FIG. 8.—*Striped or Guadaloup.*

allowed to be come very dry. Yet these plants did about as well in the field as those which had been more carefully handled.

DWARF JAPANESE. Japan. Nos. 21 and 23, Fig. 1. This is an exceedingly slender and dwarf sub-variety of the last, with smaller and earlier more pyriform fruits.



FIG. 9.—*Round White.*

3. *Experiences in Crossing.*—In

1889 numerous crosses were made for the purpose of studying the effect of pollen and of producing types which should combine some of the most desirable features of existing varieties.

The basis of the first series, which we will call *Series A*, was the well known Round White, crossed with pollen from Black Pekin. Two more distinct types could not be found, and we hoped to combine the characters of earliness and productiveness of the former, with the beauty of form and color of the latter.

In the second series, *B*, Giant Round Purple was crossed with pollen from the beautiful White Chinese.

In the third series, *C*, Long White was crossed with pollen from Black Pekin, thus giving a chance for comparison with the first series.

All the seeds resulting from these crosses were sown in 1890 on a gentle southern slope, the soil being rich sandy loam with clay subsoil. All were given good tillage and had as nearly as possible the same conditions. There were no immediate effects of crossing in these experiments.

The results of the experiments are recorded below :



FIG. 10.—*White Egg*.

Series A. Round White×Black Pekin.

In general, the mature plants were intermediate between the parents in size and character. The young shoots were much like the pistillate parent — Round White — but as they became older, the upper surface of the stems, the petioles and the veins of the leaves assumed the purple tinge of the male parent. In form and size, the larger part of the fruits seemed to vary in the direction of the pistillate parent, many of them being decidedly ovoid in form and very small. A few were larger, and had somewhat the form of the staminate parent. Frequently the same plant would produce mature fruits two inches and others five inches in diameter. In color the fruits were purple while young, — first month or so, — usually dark purple with lighter apex. In some instances this color was retained till time of edible maturity ; but as a rule, the dark purple changed to a dull greenish hue, and the light apex became metallic gray with a faint tinge of purple, and streaks of grayish-purple extended towards the base. Fig. 12 shows the extent of variation, or a fruit of every type obtained. Compare with this the characters of the parents as shown in Figs. 9 and 2.



FIG. 11.—*Early Dwarf. Purple.*

Series B. — Giant Round Purple $\times$ White Chinese. So far as beauty of form and color is concerned, this series is by far the most promising of the three crosses. The plants in this series, as in the former, were as a rule intermediate between the parents. Much of the vigor of the pistillate parent was transmitted to the offspring, but the leaves were smaller and less distinctly lobed.

In form the fruits, as a rule, resembled the staminate parent —

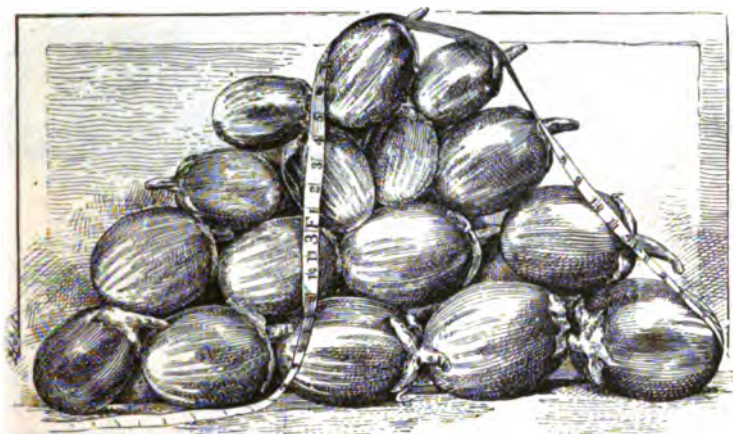


FIG. 12.—*Extent of variation in the "A" crosses.*

White Chinese, — but they were of greater diameter. The color at edible maturity was rich dark purple, with lighter apex. When fully mature — that is when left for the seed to ripen — the light purple apex became gray, then yellowish like the staminate parent, while the dark purple body of the fruit became dull green. One of the types of this series is very promising. It combines somewhat of the shape of the two parents. It is somewhat smaller than Black Pekin but still large enough for market purposes while it is of convenient size for table use. The full extent of variation in this series is shown in Fig. 13.

Series C. Long White $\times$ Black Pekin. In this series, the effect of the staminate parent in giving color to the foliage was more marked than in series A. In no case was there an absence of the purplish tinge of Black Pekin, and frequently the color was nearly as deep as in the parent. The fruit was of intermediate color, but with the purple predominating. In form a few of

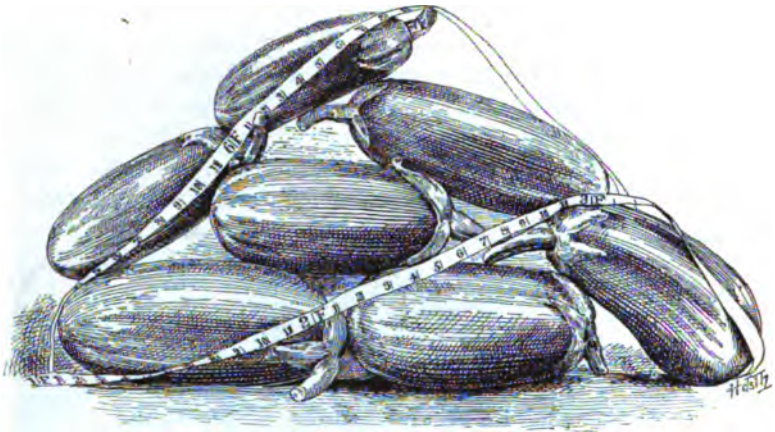


FIG. 13.—*Extent of variation in "B" crosses.*

the fruits resembled the staminate parent ; and many resembled the pistillate, while others were entirely distinct.

This is the least promising of the series, although one fruit, shown at the extreme left in Fig. 14, is perhaps the most distinctly marked of any type which we have obtained and it possesses several good points. Its particular merit is in its squareness which is novel and would allow of close packing. It is violet purple in color and very solid. This fruit was laid away in a warm attic where it kept in good condition until the first of February. Fig. 14 shows the extent of variation.

The difference in productiveness of the different series was very marked :

Series.	No. Plants.	No. Barren plants.	Per cent. Barren.
A.	91	21	22
B.	137	89	65
C.	117	93	60

The figures indicate that the highly prolific character of Round White in the first series is to a large extent transmitted to the offspring. In series C, the same staminate parent was used, but we find the offspring very deficient in productiveness. As the plants were grown side by side, under the same conditions at all times, we must ascribe the difference to the effect of the pistillate parent. The season was very dry when the plants should have been in



FIG. 14.—*Extent of variation in "C" crosses.*

full bloom, and later it was cold and wet. This may account for the high percentage of barren plants.

In every case of artificial pollination of egg plants we have obtained fewer seeds than from those left to mature. A few seeds are produced at the apex of the fruit, but most of the ovules remain undeveloped, and may be seen as minute black or brown specks in the mature fruit. The cause of this failure to produce seeds is not clear. It could not have resulted from an insufficient amount of pollen, for in all crosses, unless for special reasons, an excess of pollen was applied. There are several complications in the matter, however, and to determine the laws controlling the influence of pollen is a part of our endeavor in future investigation.

We know that in case of English forcing cucumbers, and some other plants, the pericarp is frequently developed without the action of pollen on the ovules, and is consequently seedless. From observations during the present season, it would seem that the egg-plant may be included in the list of such plants. This is a phenomenon we were not prepared for, hence made no extensive tests to determine the percentage of fruits that would be developed. In two or three instances, however, flowers were emasculated and carefully protected by paper bags, and were left without pollination. Perfect fruits were produced; but when opened, they were found to be absolutely seedless and very solid.

Numerous crosses and selections have been made in these series and elsewhere for future investigations.

SUMMARY.

1. Egg plants are adapted to cultivation in the north. The requisites of success in growing them are these : early starting ; warm quarters ; vigorous plants ; rather late transplanting to the field ; warm, rich and rather moist soil ; constant attention to potato beetles ; frequent cultivation.

2. The best varieties for private use are Early Dwarf Purple, Early Long Purple, White Chinese, with perhaps Black Pekin for late.

3. The best market varieties are New York Improved and Black, Pekin with perhaps Early Long Purple for the first demands.

4. In crossing different races of egg plants, the purple-fruited types appear to be stronger in their power to transmit color to offspring than do the white-fruited types ; and this appears to hold whether the purple type is used as the staminate or the pistillate parent.

5. The white-fruited types appear stronger in the power to transmit form and productiveness.

6. Fewer seeds are produced by flowers artificially pollinated than by those left to mature, even though an excess of pollen is used.

7. It is probable that the egg-plant may be included among those plants which are capable of producing fruit without the aid of pollen.

L. H. BAILEY.

W. M. MUNSON.

II. BOTANY OF THE EGG PLANT.*



FIG. 15.—*Solanum Melongena*, var. *esculentum* (ordinary form).

Linnæus described the egg-plant as *Solanum Melongena*. Dunal (1816)¹ divided the garden varieties into two species, which he called *Solanum esculentum* and *S. ovigerum*,

dropping Linnæus' name because it included so many types.

*In this study I have consulted the collections of books and specimens at the Gray Herbarium, Cambridge, and the Torrey Herbarium, New York, and Dr. E. Lewis Sturtevant has placed in my hands his collections of drawings.

¹Solan. Synop. 208, 210.

Later,¹ 1852, Dunal erected one of his varieties of *S. esculentum* into specific rank and gave it the name of *S. serpentinum* of Desfontaine. Dunal's species have usually been regarded as not well founded. So early as 1832 Nees von Esenbeck² united his species into the original *S. Melongena* of Linnæus, and he also referred to the same species the mad-apple of the herbalists, *Solanum insanum* of Linnæus. The mad-apple was supposed to drive those mad who ate it, a belief which calls to mind the reputed poisonous nature of the tomato in the early days. Nees regards this plant as probably the original form of the egg plant, although it appears at first sight to bear little resemblance to the cultivated plant. The plant is often exceedingly spiny, the fruits

are small and hard and the flowers are borne in clusters of three or four. But the



cultivated egg plant varies greatly in all these characters. It is particularly variable in spinescence, and Clarke records³ that in India "as an escape from cultivation it becomes often intensely prickly." In fact, the spin-

FIG. 16.—*Solanum Melongena*, var. *esculentum*.
Small form (White Egg).

escence is so inconstant that I can place no dependence upon it as a classificatory character, as Dunal and others have done. The same variety may vary from strongly armed to unarmed. The character of the fruit of the cultivated plant is so various that one need feel no hesitancy in accepting, upon this ground, the mad-

¹D. C. Prodr. xiii. 2, 355, 357, 358.

²Trans. Linn. Soc., xvii. 48.

³Hooker's Fl. Brit. India.

apple as the original of the egg plant. In several cultivated egg plants the fruit is so small and hard as to be practically inedible, and it is often no longer than that represented in early pictures of the mad-apple'. The inflorescence of the mad-apple, although several-flowered, is not essentially different from that of the egg plant. As a rule, egg plant flowers are borne singly, but there is always a distinct joint or elbow in the pedicel which marks the loss of the extra flowers. Occasionally a cultivated plant produces several-flowered inflorescence, but in such cases only the lowest flower is perfect; and Clarke says that when the egg plant escapes in India "the peduncle carries one to five fruits." It is not improbable that a more careful study of the inflorescence of the egg plant may throw light upon the barrenness of some plants. Du-



FIG. 17.—*Solanum Melongena* var. *depressum*
(Early Dwarf Purple.)

nal¹ renames the mad-apple *Solanum melanocarpum* because he considers Linnæus' name, *S. insanum*, inappropriate, and indefinite in application. All later writers refer Dunal's name to *S. Melongena*. There appears to be unanimity in regarding the *S. insanum* of Linnæus as the original type of the egg plant.

¹Cf. Fuchsius, 1542, 533; Rosslyn, 1550, 117; Tragus, 1552, 894; Lobel, Obs. 1576, 1591; Cam. Epit. 1586, 820; Gerard, 1597, 274; Smertius, 1612, t. 20 f. 1; Dod. 1616, 458.

²D. C. Prodr. l. c.

This species is supposed to be native to India, although Clarke does not know it as truly wild¹.

I have divided the varieties of cultivated egg plant into three groups :



FIG. 18.—*Solanum integrifolium* (Ethiopian).

I. *Solanum Melongena*, Linn., var. *esculentum*, Nees. Trans. Linn. Soc. xvii, 50, 49. (Figs. 15 and 16). (*S. esculentum* and *S. ovigerum*, Dunal). Plant stout and erect, mostly tall ; leaves and branches more or less densely scurfy ; leaves mostly conspicuously angled or lobed, thick ; flowers large and thick on stout peduncles ; fruit various, globular or oblong, white or purple. The ordinary form of the egg plant is well shown in Fig. 15,

¹The synonymy of the egg plant as given by Clarke in Flora of British India is as follows : *Solanum incanum* and *S. insanum*, Linn. *S. Zeilanicum*, Scop. *S. undatum*, Lam. *S. longum*, Roxbg. *S. ovigerum*, *S. esculentum*, *S. heteracanthum*, *S. melanocarpum*, *S. sativum*, *S. pressum*, and *S. Cumingii*, Dunal.

drawn from a specimen of the New York. A very low and dwarf form with rounded and barely undulate leaves is shown in Fig. 16. This form has much smaller flowers, also, but I am unable to find good botanical characters to separate it from the larger forms. The Round White affords a transition from this to the robust varieties.

II. Var. *serpentinum*.

S. serpentinum, Desf. Dunal, DC. Prodr. xiii. 2, 358, (No. 18, Fig. 1). This differs from the var. *esculentum* chiefly in the greatly elongated fruit, which is curled at the end, and perhaps it is not worth separation. It is the most singular egg plant which we have grown.

III. Var. *depressum*. (Figs. 17 and 11).

Plant low, weak and diffuse, dark colored, nearly smooth, always spineless; leaves small and comparatively thin, more entire, often scarcely angled; flowers small, mostly long-peduncled; fruit purple, pyriform. I am not aware that botanists have ever noticed this type of egg plant, although I am inclined to think that Rumphius meant to portray it in his figure 85¹. Dunal² refers to Rumphius' description but thinks his figure incorrect. I think that this is a distinct species.

Solanum integrifolium, Poir. (Fig. 18. No. 17, Fig. 1). This species is sold as the Chinese Scarlet and Ornamental egg-plant, and it is probably the one which has been lately distributed as a great novelty under the name of tomato egg plant. It goes under the name of *Solanum coccineum*. It is undoubtedly the *Solanum Texanum* of Dunal (l. c. 359), which, as Asa Gray³ determines, is probably not Texan nor even American. It is undoubtedly identical with Poiret's *S. integrifolium*, as, in fact, Dunal himself suggested. I once thought that the common name, Chinese egg plant, might throw some light upon the nativity of this species, but it appears to have been first known as the Ethiopian apple (*Mala Æthiopica*, Dodoens, 1616). Its nativity appears to be wholly unknown. Dunal says that *S. integrifolium* is a native of Mauritius, but Baker, in his flora of Mauritius, does not mention it. It is probably African. At any rate, it appears to be proper

¹Rumph. Amb. 5, t. 85.

²DC. Prodr. l. c. 355.

³Synop. Fl. ii. 227.

to recall the name under which it was long known in early times, and I have therefore called it the Ethiopian solanum or egg plant. This species was figured by Dalechamp¹ in 1587 as *Cap-sicum rotundum*. Morison² figured it in 1715 and Jacquin³ gives an excellent colored plate of it.

The Ethiopian egg plant is a coarse plant three feet high with large lobed leaves and the stems, petioles and midribs armed with strong and very sharp spines a half inch long. The small white flowers are usually borne in clusters of two to six. The fruit is small, rarely much exceeding two inches in diameter, bright scarlet or yellow and conspicuously lobed after the manner of the old Early Red tomato. We have grown two types of this plant, one of strong upright growth with purple stems, petioles and midribs, the other of spreading habit and lighter color. The species is only curious and ornamental, the fruits not being eaten.

L. H. BAILEY.

¹Hist. Gen. 633.

²Plant. Ox. sect. 13, t. 2.

³Hort. Vind. t. 12.

CORNELL UNIVERSITY

Agricultural Experiment Station.

BULLETIN 27.

AGRICULTURAL DIVISION.

MAY, 1891.

THE PRODUCTION AND CARE OF FARM
MANURES.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1891.

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Those desiring this Bulletin sent to friends, will please send us the names of the parties.

BULLETINS OF 1891.

26. Experiences with Egg Plants.
27. The Production and Care of Farm Manures.

THE PRODUCTION AND CARE OF FARM MANURES.

In Bulletin XIII was given the amount of loss of fertilizing matters suffered when manure is allowed to lie exposed to the weather for a considerable period of time. Since then other trials have been made in the same line the details of which are given herewith, and will be found in general to coincide with those already published.

This bulletin, like No. XIII, is illustrated with sketches from photographs of some farm yards that we have seen from car windows in passing through the state. In fact one is a reproduction of one of those formerly published. The reason for this is, that having recently had occasion to repass this place we found the same condition of affairs still existing. Hence the reproduction and hence, we conclude, the necessity of this bulletin to many of those who have already read No. XIII.

HORSE MANURE.

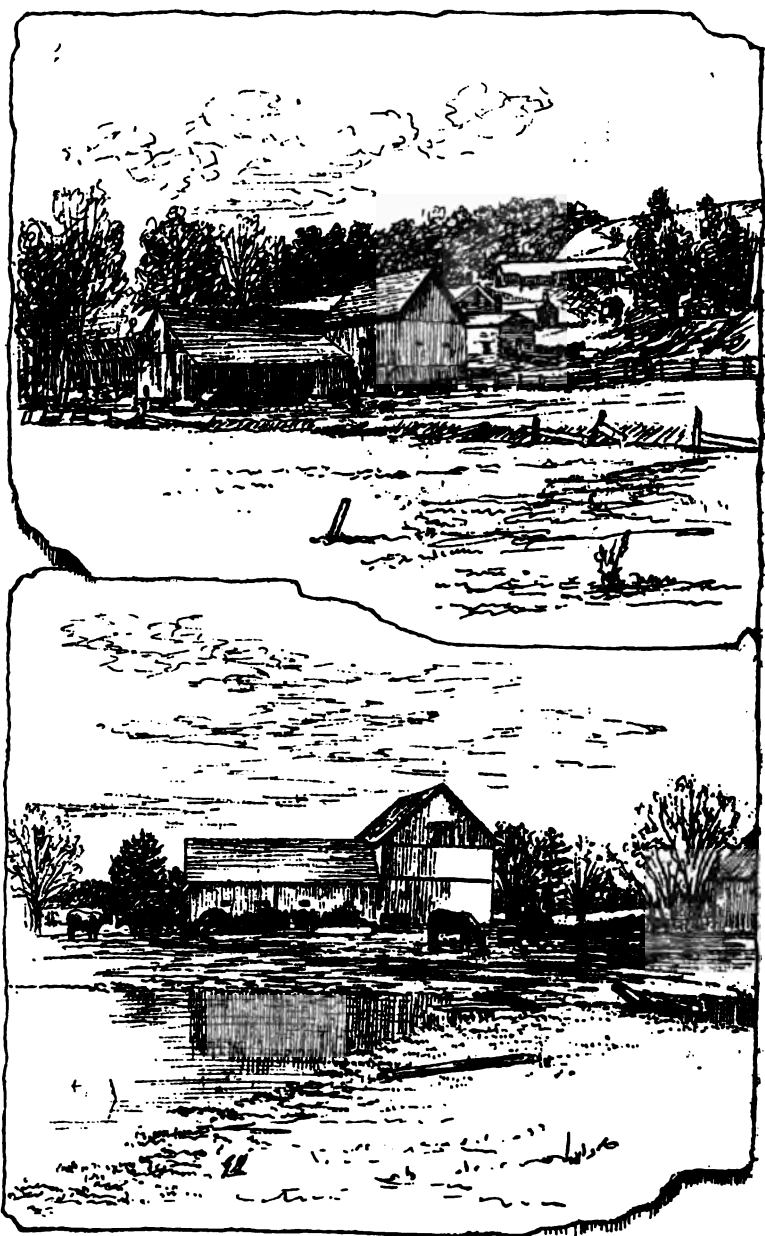
In the experiments of 1889 published in Bulletin XIII a small amount of horse manure was exposed in a loose box for a period of six months and was found to have lost in that time about 42 per cent. of its fertilizing matters. In the experiments of 1890 it was determined to make the experiment on a somewhat larger scale so that the conditions might more nearly approach those of an ordinary manure pile. Accordingly the horse manure was saved from day to day till a pile of two tons had been accumulated. This was done from April 18 to 25, 1890. Cut wheat straw was used plentifully as bedding, the relative amount of straw and manure being as follows :

3319 lbs. excrement.

681 lbs. straw.

4000 lbs. manure as put in the pile.

Analysis was made of both manure and bedding as it was put in the field and of the residue as a whole as it was taken up at the end of the trial. The analysis of the fresh material is



The Waste of Manure.

given below and for purposes of comparison the analysis of the manure of 1889 is added.

	Composition of horse manure.		Composition of wheat straw bedding. Per cent.
	Experiments of 1889. Per cent.	Experiments of 1890. Per cent.	
Water.....	70.79	72.00	6.70
Nitrogen.....	.51	.49	.61
Phosphoric acid.....	.21	.37	.28
Potash.....	.53	.90	.70
*Value per ton.....	\$2.30	\$2.80	\$2.85

*In Bull. XIII nitrogen, phosphoric acid and potash are valued at 17.7, and 4 cents per pound respectively. In this bulletin the values are changed to 15.7, and 4.5 cents to correspond with the revised values of commercial fertilizers for 1891, and the value of the 1889 manure is also changed to correspond.

It will be seen that the manure used in this experiment was considerably richer in both phosphoric acid and potash than that used the year before. The manure was put in a place where the drainage was so good that all water not absorbed by the manure ran through and off at once. It remained exposed from April 25 to September 22 at which time it was carefully scraped up, weighed and a sample taken for analysis.

The season of 1890 was a very wet one as is shown by the following table of rainfall taken from the reports of the New York State Meteorological Bureau.

MONTHS.	Rainfall, 1890. Inches.	Average rainfall for 12 years. Inches.	Excess + or deficiency —. Inches.
April.....	3.34	2.00	+1.34
May.....	6.60	3.69	+2.91
June.....	4.94	3.73	+1.21
July.....	1.24	3.92	—2.68
August.....	4.92	3.18	+1.74
September.....	6.62	2.79	+3.83
Total.....	27.66	19.31	+8.35

The analysis of the exposed manure showed the following percentages of water and fertilizing constituents :

	Per cent.
Water	80.12
Nitrogen.	.45
Phosphoric acid.....	.45
Potash.....	.50

Comparing this with the analysis of the fresh manure given above we find that the percentages of water and phosphoric acid have increased, that the nitrogen has slightly decreased and the potash considerably decreased, but from the fact that the total weight decreased from 4000 pounds to 1730 pounds during the course of the experiment the percentage composition gives no indication as to the total loss suffered which is shown in detail in the table below.

	At the beginning.	At the end.	Loss, Per cent.
Gross weight.....	4000	1730	57
Nitrogen, pounds....	19.60	7.79	60
Phosphoric acid, lbs.	14.80	7.79	47
Potash, lbs.....	36.00	8.65	76
Value per ton.....	\$2.80	*\$1.06	62

*Value at the end of the amount of manure that weighed 2,000 lbs. at the beginning.

It will be seen that the loss in value is somewhat greater than the decrease in weight, and falls heaviest on the potash and nitrogen. The total loss was considerably more than in the previous year (42 per cent. in 1889 and 62 per cent. in 1890), but as in 1889 the greatest loss fell on the potash.

The greater percentage of loss in this experiment is probably due to a greater degree of "firefanging" caused by the larger proportion of straw used for bedding. It was noted at the time that the manure in the experiment of 1890 was much more firefanged than it had been in the corresponding experiment of 1889.

COW MANURE.

On March 21 to 29 a pile of cow manure containing five tons was subjected to the same conditions of exposure already described for the horse manure. The manure as put in place contained the following amounts of excrement and absorbents :

300 lbs. plaster.

10,000 lbs. total manure.

The manure was analyzed before and after the experiment with the following results :

	At the beginning. Per cent.	At the end. Per cent.
Water.....	81.40	67.03
Nitrogen.....	.47	.55
Phosphoric acid.....	.32	.51
Potash.....	.48	.85

The actual number of pounds of the various fertilizing materials, at the beginning and end of the experiment and the percentage of loss of each is shown in the following table :

	At the beginning.	At the end.	Loss. Per cent.
Gross weight, lbs.....	10,000	5,125	49
Nitrogen, ".....	47	28	41
Phosphoric acid, lbs.....	32	26	19
Potash, lbs.....	48	44	8
Value per ton.....	\$2.29	*\$1.60	30

*Value at the end of the amount of manure that weighed 2,000 lbs. at the beginning.

It will thus be seen that the total waste was scarcely half in the cow manure of what it was in the horse manure. The fermentation of the cow manure was not sufficient to cause any "firefanging" at all. It is worthy of note that in this experiment the loss of potash was very slight in comparison with the phosphoric acid and nitrogen; in all of our other experiments the heaviest loss has been on the potash.

In the following summary is given the results of all the trials we have made on the wastes of manure, by leaching and fermentation.

	Value per ton at beginning.	Loss per ton.	Loss per cent.
1889. Horse manure in loose pile	\$2.45	\$1.03	42
1890. " " "	2.80	1.74	62
1890. Cow manure in loose pile	2.29	.69	30
1889. Mixed manure thoroughly compacted.	2.38	.22	9

It seems safe to say that under the ordinary conditions of piling and exposure the loss of fertilizing materials during the course of the summer is not likely to be much below fifty per cent. of the original value of the manure.

AMOUNT OF MANURE PRODUCED.

Numerous inquiries having been made as to the amount and value of the manures excreted by the different farm animals in a given length of time, we have endeavored to ascertain this as accurately as possible, with the means at our command.

Cows,—In the experiment with cows the stable was thoroughly cleaned out, the floor being water tight, and a weighed quantity of bedding and absorbents of known composition used ; the cows (18 Jersey and Holstein grades in milk) were kept in their places during the whole twenty-four hours, and the manure carefully collected as it was excreted, sufficient bedding and absorbents being used to make the collection easy and complete. The cows consumed 114 lbs. of hay, 893 lbs. of ensilage, 186 lbs. beets, and 154 lbs. of a mixture of 12 parts wheat bran, 9 parts cotton-seed meal, 3 parts corn meal and 1 part malt sprouts. The other details of the experiment are shown in the table.

	18 cows for 1 day.	Average per cow per day.
Weight of cows, lbs.....	20380	1132
Food consumed, lbs.....	1347	75
Water drank, lbs.....	876	49
Total excretion, lbs.....	1452.5	81
Nitrogen, lbs.....	7.35	.41
Phosphoric acid, lbs.....	5.01	.28
Potash, lbs.....	7.40	.41
Value of nitrogen.....	\$1.10	\$.06
“ Phos. acid.....	.35	.02
“ Potash.....	.33	.02
Total value.....	1.78	.10

The mixed excrement had the following per centage composition :

	Per cent.
Nitrogen.....	.51
Phosphoric acid.....	.35
Potash.....	.51
Value per ton.....	\$2.46

A few days later a second trial was made with four of the same cows used before and the solid and liquid excrement carefully collected and analyzed separately. The conditions of food, water etc., were almost identical in the two trials, as is shown by the following comparative table :

	1st Trial.	2d Trial.
Average weight.....	1132	1178
Average food eaten.....	75	76
Average water drank.....	49	40
Average total excrement voided.....	81	82

The four animals yielded in twenty-four hours 255 lbs. of solid and 72.25 lbs. of liquid excrement, which had the following percentage composition :

	Solid. Per cent.	Liquid. Per cent.	Mixed. Per cent.
Nitrogen	.26	1.32	.49
Phosphoric acid.....	.28	—	.22
Potash	.20	1.00	.38
Value per ton.....	\$2.08		

The amount and value of the fertilizing materials would therefore be

	Solid.		Liquid.		Both.		Average value per cow per day.
	Lbs.	Value.	Lbs.	Value.	Lbs.	Value.	
Nitrogen	.65	.10	.95	.14	1.60	.24	.06
Phos. acid.....	.71	.05			.71	.05	.01
Potash	.50	.02	.72	.03	1.22	.05	.01
Total	1.86	.17	1.67	.17	3.53	.34	.085

The average of the two trials shows that well fed cows, yielding milk heavily, may be counted upon to return nearly ten cents' worth of valuable fertilizing materials per day ; and the last trial shows that the liquid excrement is of equal value with the solid.

Another trial made several years ago* in a somewhat different way gave the following results as the value per day of the excrement voided by milch cows. Three cows of an average weight of 1192 pounds consumed in three days 292 pounds of fodder

*Third report of the Cornell University Experiment Station for 1883-4 and 1884-5, page 10.

(clover hay 122 lbs., corn stalks 41 lbs., cotton-seed meal 45 lbs., malt sprouts 42 lbs., corn meal 42 lbs.) and yielded 285 lbs. of milk. The manure produced was 802 pounds including 45 pounds of corn stalk bedding. In the food consumed there was contained nitrogen, phosphoric acid, and potash to the value of \$1.60, reckoning at the prices used in this bulletin. Allowing that the manure would contain 80 per cent. of the fertilizing materials contained in the fodder, the manure for the three days would be worth \$1.28 or 14⅓ cents per cow per day, or quite a little more than we found by actual analysis of the manure in our investigations recorded above.

Horses,—The determination of the amount of excrement was made by carefully collecting the manure made by the ten horses in the University barn during the time they were in the stable, for a period of 11 days including one Sunday. During this time the bedding used was also weighed and separately analyzed. The horses were mostly grade draft horses of about 1400 lbs. weight doing heavy work and liberally fed on oats and hay. During the 11 days of the experiment 3461 lbs. of clear excrement of the following percentage composition was voided :

	Per cent.
Nitrogen.....	.47
Phosphoric acid.....	.39
Potash.....	.94
Value per ton	\$ 2.79

The amount and value of the fertilizing materials would therefore be :

	10 Horses for 11 days.	Average per horse per day.
Nitrogen, lbs.....	16.27	.15
Phosphoric acid, lbs	13.50	.12
Potash, lbs.....	32.53	.30
Nitrogen, value	\$ 2.44	\$.02
Phosphoric acid, value	.81	.01
Potash, value.....	1.46	.01
Total.....	\$4.71	.043

The horses therefore returned in the manure during the time that they were in the stable rather more than four cents each per day, in about 32 lbs. of excrement. In two trials where the manure was collected on Sunday when the horses were in the stable all the time (Bulletin XIII, pages 153 and 154) we found that the average amount excreted per horse was about 56 lbs. per day ;

so that, according to these results, the four and one-third cents represents almost exactly three-fifths of the total excrement voided. Of course when horses are at work on the farm the remaining two-fifths is largely saved, otherwise it is almost wholly lost.

Sheep,—For this trial tight galvanized iron pans, covering the whole surface of the pen were used: the sheep were kept continuously upon them and enough weighed straw bedding, of known composition, was used to keep them dry and clean. The sheep were grade Shropshires, of medium size, and were well fed on grain, beets, and hay. The experiment lasted for $33\frac{2}{3}$ days with three sheep, during which time 723 lbs. clear excrement of the following percentage composition were obtained:

	Per cent.
Nitrogen.....	1.00
Phosphoric acid.....	.08
Potash.....	1.21
Value per ton	\$4.19

The other details of the experiment were as follows:

	3 Sheep for 33 $\frac{2}{3}$ days.	Average per sheep per day.
Weight of sheep.....	426	142
Food consumed.....	536	5.3
Water drank.....	765	7.5
Total excrement	723	7.2
Nitrogen, lbs.....	7.21	.071
Phosphoric acid, lbs.....	.60	.005
Potash, lbs.....	8.74	.086
Nitrogen, value.....	\$1.08	\$.01
Phosphoric acid, value.....	.04	.0004
Potash.....	.39	.004
Total value.....	\$1.51	.015

The most striking thing in regard to the sheep manure is the extremely low percentage of phosphoric acid. It will be noted that we obtained, in valuable fertilizing materials, about one and one-half cents' worth per sheep per day.

Swine,—The determinations of the amount of manure produced by swine were made in the same general way as the sheep, i. e., by keeping the swine continuously upon tight galvanized iron pans and weighing and analyzing the bedding separately. Two determinations were made, with two lots of swine fed on different rations; one lot known as the carbonaceous lot, were fed nothing but corn meal: the other lot known as the nitrogenous lot was fed a ration of two parts corn meal and one part flesh meal. It will be noted that the excrement differed very materially both in amount and quality, as is shown by the following analysis:

	Nitrogenous. Per cent.	Carbonaceous. Per cent.	Average. Per cent.
Nitrogen	.92	.74	.83
Phosphoric acid	.06	.01	.04
Potash	.64	.58	.61
Value per ton	\$3.41	2.94	3.18

The other details of the experiment are shown below.

	Nitrogenous.	Carbonaceous.	Average.	
	Four pigs in seven days.	Four pigs in seven days.	Four pigs in seven days.	Per pig per day.
Weight of swine	600	426	513	128
Food consumed	122	78	100	3.6
Total excrement	146	48	97	3.5
Nitrogen, lbs	1.34	.36	.85	.03
Phosphoric acid, lbs	.09	.007	.05	.002
Potash, lbs	.93	.28	.61	.02
Nitrogen, value	\$.20	.05	.13	.005
Phosphoric acid, value	.006	.005	.005	
Potash, value	.04	.01	.03	.001
Total value	.25	.07	.16	.006

It will be seen that the value of the manure per animal per day is considerably smaller for swine than for any of the other classes of animals, amounting to but little more than half a cent a day for liberally fed thrifty shotes, of medium size.

SUMMARY.

In the table below we have grouped together the results of our determinations for the various classes of animals both as to the relative value of the manure, per ton, and the amount produced per animal and per thousand pounds live weight.

	Value per ton.	Value per animal per day.	Value per 1,000 pounds live wt. per day.	Value per 1,000 lbs. live wt. per year.
Horses*	\$2.79	\$.044	\$.031	\$11.47
“ †		.073	.052	19.12
Cows	2.27	.093	.082	29.82
Sheep	4.19	.015	.106	38.55
Swine	3.18	.006	.047	17.11

*Manure voided while at work not included.

†Total excrement calculated on the basis that three-fifths was collected in the stable.

As showing the amount of manure actually produced by farm animals we quote from some experiments carried on during the winter of 1884-5*. In the five months from October 1st to March 2d 199.25 tons, by actual weight, of manure were produced by a herd of twelve spring calves, seven winter calves, one bull, twenty-four cows, twelve horses and one colt, making fifty-seven animals in all; allowing that the twenty young animals would equal ten adults, we would have the equivalent of forty-seven full grown animals. An analysis of this manure showed that it contained fertilizing materials to the value of \$3.08† so that the 200 tons produced during the five months would be worth \$616 or \$13.10 per animal.

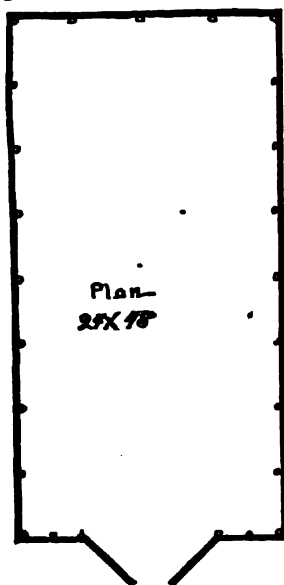


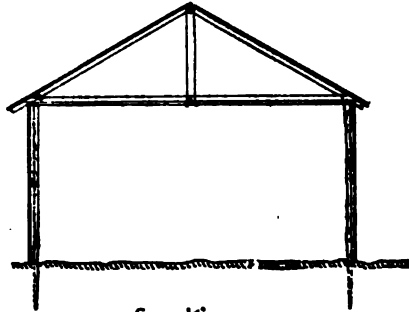
Fig 1.

We have endeavored in this Bulletin to set forth in clear and accurate statements, facts, in regard to the quantity of excrements voided by various classes of animals, and the amounts of the three leading elements of plant growth which they contain. The reader must now adapt these facts to his environment; for it is impossible to ascertain the value of a ton of manure in any given conditions. True, we have set values, but this is only that we may be able to make comparisons; we have taken the prices established by common consent for determining the comparative value of commercial fertilizers, because they are the ones in common use and not because we believe that the potash, nitrogen and phosphoric acid are necessarily worth the prices attached to them. With present prices for farm products, and under unfavorable conditions, the reader may have to divide the values given of a ton of farm manures by two and then

*Third Report Cornell University Experiment station for 1883-4 and 1884-5, p. 8.

†The values have been changed to correspond to those used in this bulletin.

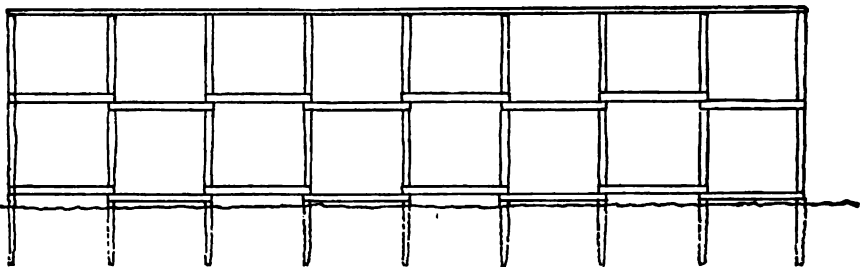
it is possible that he may have to divide it again before he arrives at the value which the manure is worth to him. The great object has been to determine the quantity of manure produced by various classes of animals, its quality, and the enormous loss sustained by the wasteful methods generally practiced in its care.



Section.
Fig. 2.

We believe that much of this waste is due to the fact that it is hard to abandon methods practiced from time immemorial and adopt new ones which are more difficult, because they are unfamiliar.

Then, too, many feel the expense of fitting up suitable receptacles for the temporary storage of manures, when from various causes it is not convenient to transport them direct from stable to field, is too great. Most farmers have had little experience in planning and erecting buildings; hence they naturally think that they must be built much after the fashion of those constructed by our grandfathers when timber was worthless and carpenter work superlatively cheap. The new idea that the manures should be as carefully preserved from unnecessary waste as any other product of the farm is hard to put in practice after having stored for forty years the farm yard manures under the eaves upon the steep hillside which forms one border of the running brook.



Side View of Frame, without roof rafters

Fig. 3.

The accompanying figures, 1, 2 and 3, show the ground, plan and elevation of the frame of a cheap, durable, and easily constructed covered yard. Long posts or poles, eight inches in diameter, at the butt are set in the ground two feet deep and six feet apart. Upon these are spiked two by four scantling about four feet apart for nailing girts and a plate two by six is nailed on top of the posts which have been previously sawed off to a line after the girts have been spiked to them. Round poles flattened at the ends, or two by six joists doubled, spiked to the heads of the posts will tie the building together. Ten feet will be quite high enough for the story; and one story will suffice if no straw is to be stored above except that which is placed there to exclude the cold. A few poles or old rails laid on these cross ties which bind the building together will suffice to sustain the weight of the straw while the straw will exclude the cold, and absorb the moisture, far better than an expensive matched ceiling.

On the inside of the posts which have been set in the ground flattened poles, rails, or slabs or cheap boards may be nailed hori-

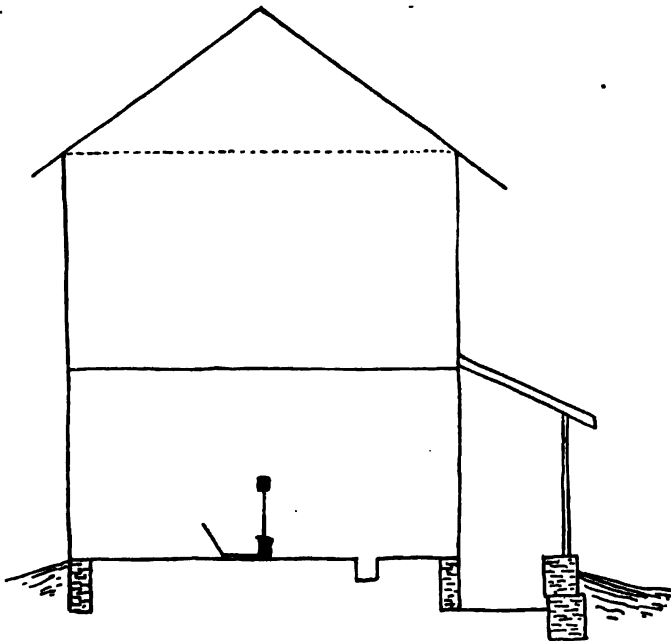


Fig 4.

zontally and the space between the outside vertical boarding and the inside horizontal boarding may be filled with straw. This kind of a wall is far drier and more comfortable for the animals than one made of costly stone or brick.

If it is desired to have a place to store straw the building should be higher, the joists stronger and more numerous than in the one-story building, and they will all have to be supported by a timber, supported by posts, placed under their centers. The roof should be steep and can be made of any material which will shed water. When the posts which have been set in the ground have rotted off or are much decayed they may be sawed off even with the ground and supported by placing underneath each one of them a large flat stone. Whenever the building is treated in that way it will be necessary to brace it thoroughly. It might be well in a windy country to brace so wide a building at the start.

Such a building will be inexpensive and reasonably durable; It will serve as a place for depositing manure when needed; it will shelter the animals while they are being watered and the stables are being cleaned and aired and give facilities for preventing loss of valuable fertilizing material either by leaching or firing. Many stables are situated something similar to what is shown in figure 4; by adding a cheap leanto as shown, a receptacle for caring for the manure is easily provided. The outside boarding of the leanto should be for a part of the way at least put on horizontally and hung in the form of flat doors so that the manure can be easily loaded on a wagon standing on the outside of the building.

I. P. ROBERTS.

CORNELL UNIVERSITY

Agricultural Experiment Station.

BULLETIN 28.

HORTICULTURAL DIVISION.

JUNE, 1891.

EXPERIMENTS IN THE FORCING OF TOMATOES.

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1891.

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28. Experiments in the Forcing of Tomatoes.

EXPERIMENTS IN THE FORCING OF TOMATOES.

The winter forcing of tomatoes is little understood by gardeners, and the literature of the subject is fragmentary and unsatisfactory. Yet it is a promising industry for all the older parts of the country, particularly in the vicinity of the larger cities. Winter tomatoes always find a ready sale at prices ranging from forty to eighty cents per pound. The crop is one which demands a high temperature, an abundance of sunlight, and great care in the growing, but the profits, under good management, are correspondingly high. Tomato forcing is one of the most interesting and satisfactory enterprises for the winter months. We have made careful experiments upon it during two winters and our efforts have met with uniform success.

The house.—A light and tight house is essential, and it must be high enough to allow of training the plants. At the present writing we are growing tomatoes in five houses, of different height and pattern. Our preference is for a house which was designed for tomatoes, having a two-thirds span and the ridge eleven feet from the ground. The house is twenty feet wide and built upon a sharp slope. It follows the lay of the land, running nearly east and west. A north and south house would be preferable, probably, because of the more even distribution of light. The framework is unusually light and the glass is 14x24 inches. Our second choice is for a house in all respects like the first, except that the ridge is two feet lower. This does not allow of such high training of the plants as is possible in the other house. We also grow tomatoes for a late spring crop in a pea and lettuce house.

The importance of direct and strong sunlight was well illustrated in our lightest house last winter. At one end of this house is a low building which shaded a part of the plants after half past two or three o'clock. The plants within three or four feet of this

building, which were thus deprived of direct sunlight for half the afternoon, bore no fruits whatever, although they were strong and vigorous. At six and seven feet away some fruits were borne, but it was not until some fifteen or twenty feet from the building that a full crop was obtained. It should be said that the winter at Ithaca is unusually cloudy, and therefore the lack of sunlight may have been more injurious to the crop than in sunnier climates, but I think that the effect would have been marked in any place. The ill effects of shade are also visible upon the north benches of houses running east and west, where the plants are shaded somewhat by those in the center of the house. During the middle of winter the north bench in our house produces no more than half as much fruit, even in an unequal-spanned house, as those in direct sunlight. The plants in partial shade grow as well and as large as those in full sun, and they often blossom well, but the fruit does not set. The proper temperature for tomatoes is from 60° to 65° at night and ten degrees higher for dull days. On bright days it may be allowed to run higher, although we always wish to ventilate at 75° , but a temperature of 90° or even 100° can do no harm. Until fruit begins to set, the atmosphere should be kept moist, especially on bright days, but the setting of the fruit is hindered by a humid atmosphere.

Soil and fertilizers.—Nearly all writers upon house culture of tomatoes assert that the soil should be only moderately rich because heavily manured plants are over vigorous in growth and are generally unproductive and are particularly liable to disease ; and the additional cost of training is said to be considerable. Our experience emphatically contradicts this supposition. Heavily manured plants undoubtedly require more care in the pruning, and it is possible that when not properly handled they may be more liable to mildew because of the dense and crowded growth ; but on the other hand, we always get the best yield from the strongest plants, and we find the extra cost of training to be of little account. We grow the plants in rich garden loam to which is added a fourth or fifth of its bulk of well rotted manure, and when the plants begin to bear, liquid manure is applied every week, or a top-dressing of manure is given. To those unaccustomed to forcing-house work this may seem extravagant fertilizing ; but it must be

remembered that in house culture the roots are confined in a small space and they have little chance to search for food. And as a matter of practice, we find this heavy manuring to be essential to satisfactory results. It is strange that the the notion that tomatoes require a comparatively poor soil should ever have become so widespread. It has been almost universally held in regard to out-door tomatoes, but our own experiments, as well as those of others, have shown conclusively that it is erroneous.

FIG. 1 shows in a graphic way the value of stable manure as compared with some concentrated fertilizers for indoor tomatoes. All the plants were grown in 6-inch pots of rich garden soil, and the bottom of each pot was plugged to prevent any loss by drainage. The plants received the following treatment in the order named, beginning at the left: garden soil alone; salt added, 2 grammes; phosphate of soda (Na_2HPO_4), $1\frac{1}{2}$ grammes; nitrate of soda

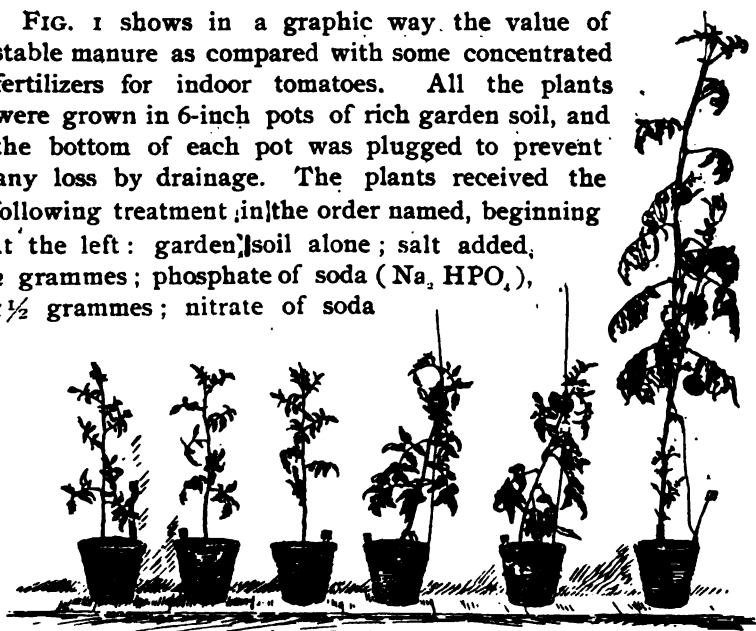


FIG. 1.—Fertilizer Treatments.

(NaNO_3), $1\frac{1}{2}$ grammes; nitrate of ammonia (NH_4NO_3), $1\frac{1}{2}$ grammes; old stable manure and soil equal parts. It is worth noting that the nitrate pots give much larger leaves than the first three pots, and the plants are also in bearing. These results are selected from a large series of experiments now under progress by J. E. Rice, one of our graduate students, and are introduced here merely as an illustration of the value of liberal applications of stable manure.

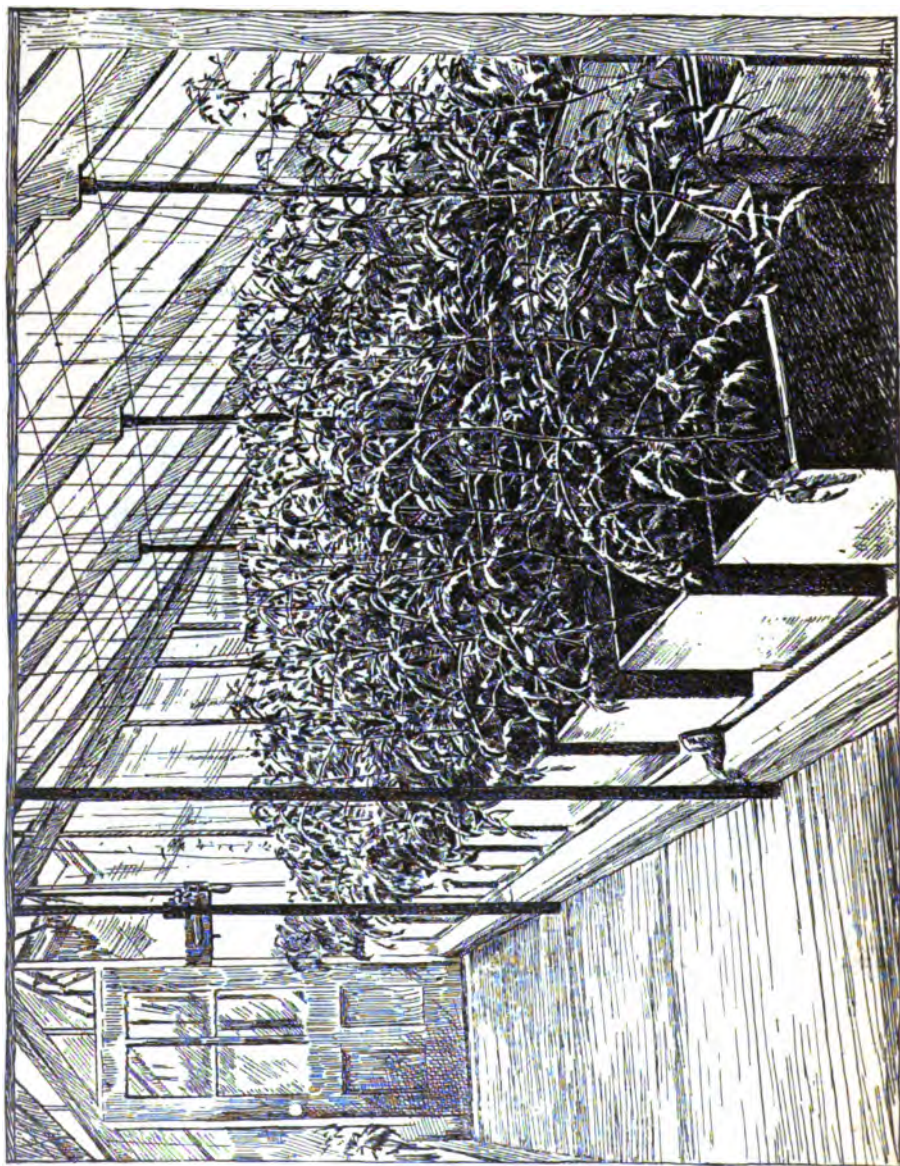


FIG 2.—View in Tomato house. Plants three months old.

Bearing age.—In this latitude it requires from four to five months to bring a forced tomato plant into bearing. Seeds which were sown the 9th of last August gave plants fit for transplanting early in September. These were planted in permanent quarters in the tomato house October 15th, and the first fruits were obtained December 28th. They continued in bearing until near the end of February, when they were trained for a second crop. Plants started November 10th were transplanted into 4-inch pots December 8th, and from these pots into permanent quarters February 25. The first fruits were picked May 6th, and May 12 the first market picking was obtained. They are now (June 4th) in full bearing. It will be noticed that the second lot grew much more slowly than the first one. This is because the plants were growing in the short and dull days of midwinter.

Arrangement of plants.—There are various methods of growing house tomatoes. Much depends upon the height of house, and arrangement of benches and heating apparatus. They may be planted in the ground or floor of the house, but I think that this is not advisable as it does not allow of the application of bottom heat and the plants grow slowly; and it is frequently an advantage to shift the plants somewhat during subsequent treatment.

I prefer to grow them over brisk bottom heat, and it is necessary, therefore, to place them upon benches. The plants may be grown in shallow beds upon the benches, or in boxes or pots. Altogether, I prefer 18-inch-square boxes, although we have had good success in beds. Fig. 2 will give some idea of the arrangement of our tomato house. The return pipes lie close upon the ground and are covered with a low platform or bench, made of 3-inch slats with inch spaces between them. The boxes are placed ten inches or a foot apart and four plants are set in each of those which are 18 inches square. A plant therefore occupies about one and one-half square feet of floor space. We have grown them in 10-inch-square boxes and also in 10-inch pots, but these dry out so quickly that we do not like them. Our boxes are a foot deep. One or two narrow cracks are left in the bottom. A good layer of potsherds or clinkers is placed in the bottom for drainage, and the box is then filled two-thirds full of soil. When the fruit begins to set, the box is nearly filled with rich soil and manure. The object of not filling the box at first is to confine the roots in

a smaller space and therefore to hasten fruitfulness—perhaps an imaginary advantage—but more particularly to allow of an additional stimulus to be given the plant at fruiting time.

We have grown an excellent crop of tomatoes on a bean bench, from which three crops of beans had been taking during the winter.* After each crop of beans the soil was loosened up and manure or manure water added if needed. The soil was again manured before the tomatoes were set. The bed is six inches deep. Upon this bed the plants were set two feet apart each way and each plant was trained to two shoots. We are now carrying a crop of tomatoes upon a bench which grew peas and lettuce during the winter. The house is not warm and light enough for winter tomatoes; nor is the house high enough, so that we are training the plants into three stems. The plants were started February 2d, and transplanted directly to the bench March 17th. They are now (June 4th) in full bloom, with some fruits set upon the older clusters. We shall expect to pick the first fruits in about a month from now.

Training.—The plants must be trained. For midwinter, when it is necessary to economize sunlight, I prefer to train plants to a single stem. Strong flax cord, the size of wool twine, is used for support. A single strand runs perpendicularly from each plant to a horizontal wire or rafter extending lengthwise the house under the roof. The plant is secured loosely to this support at intervals of a foot or so by means of some broad and soft cord, as bass or raffia. Fig. 2 shows the young plants being trained. All side shoots are pinched off as soon as they appear, and the leader is “stopped” or pinched off as soon as it reaches the glass, or sometimes when fruits begin to form. In houses of sufficient height, I like to train the plants fully six feet high. In midwinter it may be necessary to cut away some of the older leaves or to cut them in two near the middle in order to let in light. As the fruit sets, the leaves near the base of the plant begin to die and they should be picked off. Healthy plants in full bearing are often bare of leaves for the first two feet. Fig. 3 shows average plants just coming into bearing. Plants at this stage, in the lengthening days of February and March, may be expected to give ripe fruits in two to three weeks.

*For directions for forcing beans, see Bull. xxv. p. 171.



FIG. 3.—*Box culture and single stem training.*



FIG. 4.—*A stem of Winter Tomatoes.*

When the plants are set in benches, at distances of two or three feet, two or three shoots may be trained out upon diverging strings, in fan-shaped fashion. If the fan stands north and south it will probably interfere least with the light. Tomatoes are sometimes trained along under the roof as rafter plants, but this system is not adapted to commercial purposes as it darkens the house so much that few plants can be grown.

As soon as the fruit becomes heavy the largest clusters will need to be held up. A sling of raffia is caught over a joint of the plant and is passed under the middle of the cluster, as seen in Fig. 4, which shows the bearing portion of a good average plant.

Upon very strong vines the clusters sometimes "break" or push out a shoot from the end. This shoot should be cut off. Tomatoes upon clusters where this abnormal shoot was allowed to grow were generally smaller and more irregular than upon clipped shoots.

Watering.—During all the early growth of the plant the atmosphere may be kept moist, particularly in sunny days, when it is customary to wet down the walks. Care must be taken in watering. It is best to soak the soil pretty thoroughly at each watering, yet it should not be drenched. Careless watering usually leaves the surface wet while the under soil remains dry. This must be avoided. In midwinter we water our plants thoroughly about twice a week, giving no water directly to them between times. If the red spider should attack the plants the atmosphere must be kept moist, and in bad attacks the foliage should be syringed. Every care should be taken to keep the plants free from the spider, for the pest cannot well be overcome after the fruit begins to set, when the house should be kept dry. If fungi begin to attack the plants, however, the atmosphere will probably need to be kept drier.

Pollination.—When the flowers begin to appear the atmosphere must be kept dry during the brighter part of the day in order to facilitate pollination. The pollen is discharged most profusely in dry sunny days. In the short dull days of midwinter some artificial aid must be given the flowers to enable them to set. The common practice is to tap the plants sharply several

times during the middle of the day with a padded stick. This practice is perhaps better than nothing, although tests which we made during the past spring upon the value of this operation as compared with no attention were entirely indifferent in results. I am strongly of the opinion that it will pay the commercial grower to transfer the pollen by hand during midwinter. At this season the flowers are most likely to fail and the product is the most valuable ; and the tests which I am about to report concerning the influences of different quantities of pollen strengthen this advice. There are various methods of pollinating the flowers. The most expeditious and satisfactory method which I know is to knock the pollen from the flowers, catching it in a spoon, watch glass, or other receptacle and then dipping the stigmas of the same or other flowers into it. There is a time in the life of the flower when the pollen falls out readily if the atmosphere is dry enough to hold dust. This is when the flower is fully expanded and somewhat past its prime. The flower is tapped lightly with a lead pencil and the light yellow powder falls out freely. I am glad to give the experience of C. J. Pennock, Kennett Square, Penn., a Cornell graduate, upon this point. Mr. Pennock grows winter tomatoes for market, and he writes me as follows concerning the pollination of the flowers : " During the short days of winter I pollinate carefully every day, and I consider the operation necessary. I use a tool of my own make. It is a light piece of wood about 16 in. long and one-half inch square, one end of which has a slight saucer-like depression. This stick is held in the left hand with the depression under the blossom to be pollinated. Another light stick or reed is used to tap the blossom and shake out the pollen, the end of the pistil being pressed into the accumulated pollen in the depression at the same time. On a sunny day when the house is dry the operation can be performed rapidly. I have tried jarring the plants and have seen a brush used, but do not consider either as good as the above method." In the brighter days of March and later I have found no other attention necessary than keeping the house dry at midday.

But there appears to be further reason why hand pollination is profitable. In my earliest experiences in tomato forcing I was impressed with the fact that indoor tomatoes are smaller than those grown out of doors, and the midwinter fruits are usually smaller



FIG. 5.—*One-sided Fruit.*

than those produced under the same circumstances in late spring. There is also a marked tendency in house tomatoes to be one-sided, as indicated in Fig. 5. It was a long time before any reason for these facts suggested itself. I finally came to feel that this irregularity and perhaps the smallness were often due to irregular or insufficient pollination, although it is probably true that lack of sunlight has something to do with the inferior size. The first definite aid towards the solution of the problem was the result of an experiment performed early last winter by my former assistant, W. M. Munson. Mr. Munson pollinated two fruits upon the same cluster with pollen from one source, but in one flower very little pollen was used and it was applied upon one side of the stigma only, while the other flower received an abundance of pollen over the whole surface of the stigma. The result is shown in Figs. 6-8.



FIG. 6.—*The Effects of Pollination.*

In Fig. 6 the large fruit received the more pollen and it is fully four times as large as the other, which received the small amount. Moreover, the large fruit was practically symmetrical, while the

small one was one-sided. Figs. 7 and 8 show cross sections of



FIG. 7.—*Effects of pollination.*

of course, were emasculated in the bud and were securely covered with bags to prevent any interference.

Four important lessons are to be drawn from these experiments: 1. One-sidedness appears to be due to a greater development of seeds upon the large side.* 2. This development of seeds is apparently due to the application of the greater part of the pollen to that side. 3. An abundance of pollen applied over the entire stigmatic surface, by increasing the number of seeds increases the size of the fruit. 4. The pollen, either directly or indirectly, probably stimulates the growth of the fruit beyond the mere influence of the number of seeds; the growth of the solid part in Fig. 8 appears to indicate this. This secondary influence of the pollen in increasing the size of fruits, both by means of increasing the number of seeds—which necessarily demand a larger envelope

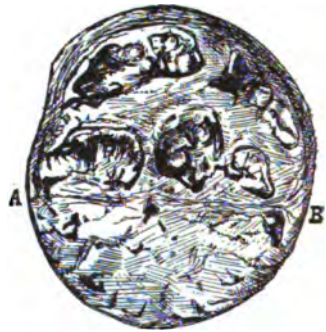


FIG. 8.—*Effects of pollination.*

*For similar results in the pollination of apples, see Bull. 31, Mich. Agr. Coll. 91 (1887).

or receptacle—and by some stimulating influence which it may have upon the pericarp itself, is well known as a scientific fact, but I do not know that it has ever been applied to the practical operations of horticulture. If I have interpreted these experiments correctly, they mean that a part, at least, of the smallness and perhaps all of the one-sidedness of house tomatoes are due to insufficient pollination, and that it will pay the grower in mid-winter to pollinate by hand and to exercise pains to apply an abundance of pollen over the whole surface of the stigma. It is possible that the same principle can be applied to some other fruits, and our experiments with other plants in this direction have already been considerable.

The development of the hard and seedless part of the small tomato (Fig. 8) is perhaps the most interesting feature of the experiment from a scientific point of view. This part must have developed because of some entirely secondary stimulus of the pollen upon the pericarp or else because of the stimulus afforded by the growth of the seeds in the other half; if neither of these propositions is true, it must follow that seedless tomato fruits may develop without any aid of pollination whatever. In any case, the query is raised if it will ever be possible to grow perfectly seedless tomatoes; we have already grown them, but can make no report as yet.

Second crop.—The crop from the one or two or three trained shoots of house tomatoes does not exhaust the vitality of the plant; consequently when the crop is well along, one or two new shoots may be trained out from near the base of the plant to produce a second crop. If the plant is carrying a load of fruit when these second shoots are being trained, liquid manure should be given once or twice a week, or a fresh mulch of old manure may be added. In the dark days of midwinter there may not be enough light to make these new shoots strong in such close planting as we practice, and it is better, therefore, to delay starting them until the fruit from the first crop is nearly all full grown. But in late February and March the new shoots may be allowed to become three or four feet long before the old shoots are cut down. Of course much will depend upon the distance at which the plants are set, the lightness of the house and the fertility of the soil. Shoots which were about a foot long when the old tops were

cut down the first of March, gave ripe fruits the first and second weeks in May. We have noticed that strong and stocky shoots from six inches to a foot long give fruits about as early as weak and slender shoots three and four feet long, and they make better plants. With judicious treatment, the second crop can be made to follow the first with an interval of four to six weeks only, although this is difficult with the close planting which we have employed. One shoot may be trained out from each plant to take the place of the old top, or two shoots may be allowed to grow and some of the old plants cut out entirely. The advantages of either practice are about equal in the box system of growing. Mr. Pennock trains his plants to a single stem for winter bearing. For later fruiting, he trains out two or three shoots from each plant. But Mr. Pennock grows his plants in beds on benches and sets them 2 ft. x 2½ ft. In any case, each of the second shoots should bear as much as the first one did, and usually more because of the greater amount of sunlight later in the season. The old top is cut off an inch or so above the junction of the new shoot.

Another method of obtaining the second crop is to bury the old plants. As soon as the fruit is off, the soil is removed between the plants and the stems, deprived of lower leaves, are coiled down into the hole until only a foot or so of the tip projects. The earth is then filled in over the plants, and the tip grows the same as a young plant. We have not found this method quite so satisfactory as the training out of new shoots. The yield has not been quite so heavy as from single second shoots, although fruits were obtained fully as early as from shoots which were a foot long when the test was started. But it is a somewhat laborious operation and some of the stiffer plants are apt to be cracked in the handling; and in box culture it is necessary to pull out one or two of the four plants in order to make room for the operation.

A third way of obtaining the second crop is by means of new seedling plants. This is the common method. Plants are started from seeds two or three months beforehand, and are transplanted two or three times into pots. At the final shifting they are taken from four or five-inch pots and placed in permanent quarters. At this time they should be from 18 inches to 2 feet high, or ready for the first tying up. We find that seedlings will bear about the same time and to the same extent as sprouts which are of equal

length to begin with. The preference must therefore be for the sprouts, as they avoid the previous labor of sowing and handling ; and the seedlings take up valuable room while growing.

Yields.—It will be seen from the foregoing discussion that any statement of the yield per plant of house tomatoes must be utterly valueless unless the method of training is given. The yield from two-stemmed plants will be twice as great as that from single-stem training, and the yield from double cropping of one plant will be from two to four times as much as from a single crop ; and much will depend upon the time of year. Some of the reports which have been made of enormous yields must be untrue. The true way to estimate yield is by the amount of floor space covered.

In our experience we obtain from $1\frac{1}{2}$ lbs. to 2 lbs. per stem (or plant) in midwinter and about twice as much in spring, or an average of 3 lbs. or more for theseason. This amount is produced on $1\frac{1}{2}$ sq. ft. of space. Mr. Pennock obtains from 8 lbs. to 10 lbs. to the plant for the season, but his plants cover 5 sq. ft. The practical results of the two systems are therefore about the same—about 2 pounds to the square foot ;* but the box system has some advantages in ease of manipulation, and the plants are so numerous that the loss of one by any accident is not so serious as in the other case.

We have made experiments to determine if the second crop from the plant is influenced by the amount of the first crop. The tests were made with both buried and sprout plants. For one series we used the plants which bore the heaviest midwinter crop, and for the other those which stood in partial shade and had borne nothing (see page 46). The results show that the first crop does not influence the bearing capacity of the second stage. And they also show that amount of crop is not a fixed trait of the individual plant ; *i. e.*, a plant which bears little at first may bear heavily the second time, and *vice versa*.

Varieties.—We have forced Dwarf Champion, Lorillard, Ignotum, Ithaca, Golden Queen, Golden Sunrise, Volunteer and Beauty and we are now growing Potato Leaf. Of these, the Dwarf Champion is least satisfactory. It does not grow high or

*This is over three times the yield per square foot in field culture in this latitude.

free enough to allow of convenient training, and the fruit is small and ripens slowly. Among the others there is little choice. Perhaps the Ithaca is the least desirable of the remaining ones, because of its irregularity. This is a great disappointment, for in the field plantation last year the fruits were remarkably regular and uniform, and I named and described it in the expectation that it would be a good winter tomato.* But I cannot look upon the irregularity of house tomatoes as wholly a varietal character. All tomatoes, apparently, tend to be more irregular indoors than out, a tendency for which I cannot yet give any reason. It seems to vary somewhat in the same variety at different times. The Ignotum seemed to be somewhat more irregular in the house the first winter than the second. Lorillard and Ignotum seem to hold the first place among the varieties which we have tried, although Volunteer is scarcely inferior. The Golden Queen is perhaps the best yellow. Yellow tomatoes are in little demand, but a few plants may prove profitable from which to sell fruits to those who desire to make table decorations.

Marketing.—The tomatoes are usually marketed in small splint baskets holding from four to ten pounds of fruit. Each fruit is wrapped in tissue paper and if to be shipped by rail the baskets should be lined with rolled cotton. In midwinter our fruits average from $1\frac{3}{4}$ oz. to 2 oz. each, but in late March and April the average will rise to three ounces and more. In May, well pollinated fruits often weigh seven or eight ounces. The weight of the best fruits is often increased by cutting off the smallest and most irregular ones.

Insects and diseases.—A white scale (*Aleyrodes vaporariorum*) is a common pest here on tomatoes. The imperfect insect is a small white scale-like body, preying upon the under surface of the leaves, and the mature form is a minute fly-like insect which flies about the house. It can be kept in check by fumigating with tobacco smoke. A much more serious pest is a small spotted mite, scarcely larger than the red spider. Barring the rose chafer, it is the most serious pest which I have ever encountered. The mites feed upon the under sides of the leaves, causing the upper surfaces to appear speckled with white, as shown in Fig. 9. They attack

*Bull. xxi. Oct. 1890, 84.

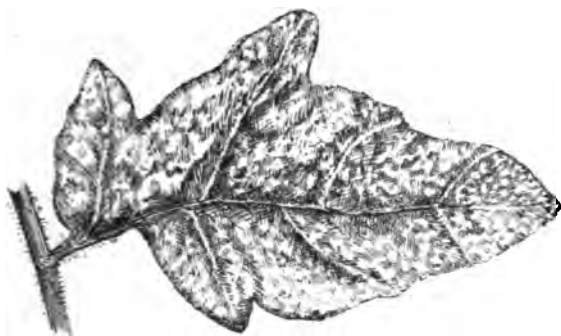


FIG. 9.—*Mite Injury.*

many plants, but tomatoes and cucumbers are favorites. We have tried numbers of remedies with great thoroughness, but in 1889-90 the only way we could keep them in check was to syringe with water so

forcibly once or twice a day as to knock them off. By the time they were fairly resettled on the plants we would knock them off again. By this alternating warfare, aided by picking and burning the worst leaves, we kept our plants in tolerable order. Lately, however, we have found that Hughes' fire-tree oil is fatal to them, as also to all kinds of lice and scales. For the mites, we use a half pint of oil to two gallons of water, and the material may be applied with a syringe or knapsack pump.

The root-gall, caused by a nematode worm (*Heterodera radicola*), often does great damage in tomato houses. We have never had this pest, but one of my correspondents in Massachusetts, a large tomato grower, has had serious difficulty with it. I advised him to remove the soil from his benches and wash the boards thoroughly with lye and then add new soil. He informs me that this treatment has proved effective.

We have not had serious difficulty with fungi. The rot of the fruit has been the worst and this has appeared chiefly in spring. Spraying with either ammoniacal carbonate of copper or Bordeaux mixture keeps the trouble in check. We prefer the carbonate of copper because it is more easily made and applied and it does not discolor the plants and fruits so much as the other. There are two or three good recipes for preparing the carbonate of copper. We dissolve three ozs. of carbonate of copper in a quart of ammonia and keep this as a stock solution. Two fluidounces ($\frac{1}{2}$ gill, 4 tablespoonfuls) is added to a pail (2 gals.) of water when desired for use.

Late in April this year a blight appeared very suddenly in two of our houses and in a very few days overran many plants and fruits. It is a cladosporium, although not the *C. fulvum* or true tomato blight. It appears as a brownish mildew-like discoloration on the leaves and fruits. Thorough applications of the ammoniacal carbonate of copper have kept it in check.

GENERAL SUMMARY.

1. The tomato can be forced for winter bearing to advantage, but it demands close and constant attention.
2. A tomato house should be very light, warm, and the roof should be at least five feet above the beds or benches.
3. An abundance of sunlight is essential.
4. The temperature should be about 60° to 65° at night and 70° to 80° during the day, or higher in full sunshine.
5. House tomatoes demand a rich soil and a liberal supply of fertilizers.
6. In this latitude, house tomatoes bear when four to five months old.
7. Tomatoes like brisk bottom heat. They may be grown in large boxes or upon benches; 18 inch-square boxes, placed about a foot apart, and containing four plants to the box, afford one of the neatest and best means of growing tomatoes.
8. Winter tomatoes must be trained. From one to three stems, depending upon the distance apart of the plants, are allowed to grow from each plant. These are trained upon perpendicular or ascending cords. The plants must be pruned as fast as new shoots appear. The heaviest clusters should be supported.
9. Water may be used more freely early in the growth of the plant than later. Wet the soil thoroughly at each watering, rather than water often. When the fruit begins to set, keep the atmosphere dry, especially during the middle of the day.
10. In midwinter the flowers should be pollinated by hand. This may be done by knocking the pollen from the flowers when the atmosphere is dry and catching it in a spoon or other receptacle, into which the stigma is thrust.
11. One-sidedness and much of the smallness of house tomatoes appears to be due, at least in part, to insufficient pollination.

a. One-sidedness appears to result from a greater development of seeds upon the large side.

b. This development of seeds is apparently due to the application of the pollen to that side.

c. An abundance of pollen applied over the entire stigmatic surface, by increasing the number of seeds increases the size of the fruit.

d. The pollen, either directly or indirectly, probably stimulates the growth of the fruit beyond the mere influence of the number of seeds.

12. The second crop of fruits is obtained by training out a shoot or shoots from the base of old plants, by burying the old plant, or by starting a new seedling crop. The first method appears to be the best.

13. House tomatoes in this latitude yield about 2 lbs. to the square foot. The amount of the first crop does not appear to influence the amount of yield in the second crop from the same plant.

14. Lorillard, Ignotum, Volunteer, Ithaca, Golden Queen and Beauty we have found to be good winter tomatoes.

15. Insect pests are kept in check by fumigating with tobacco, and the spotted mite by Hughes' fir-tree oil. Fungi are controlled by ammoniacal carbonate of copper and Bordeaux mixture.

L. H. BAILEY.

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BULLETIN 29.

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JULY, 1891.

I. Cream Raising by Dilution.

II. The Effect of a Delay in Setting on the Efficiency of Creaming.

III. Application of Dr. Babcock's Centrifugal Method, to the Analysis of Milk, Skim-Milk, Buttermilk and Butter.

IV. The Relation of Fibrin to the Effectual Creaming of Milk.

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BULLETINS OF 1891.

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CREAM RAISING BY DILUTION.

In bulletin No. XX published in September, 1890, there was published the results of some experiments on the effect of the addition of water to milk in influencing the thoroughness of creaming in which it was shown that instead of aiding the creaming, the addition of water, either warm or cold, was a positive detriment to the thorough separation of the cream.

Inasmuch as these results were contrary to the recommendation of dairy authorities and inasmuch as they were made at a season of the year when efficient creaming is most easy and with cows moderately fresh in milk, it was thought best to repeat the experiments when the cows were farther along in the milking period and when the weather was colder and creaming in general more difficult. Accordingly during the months of December, 1890, and January, 1891, another series of experiments was made, the results of which are given herewith.

All the analytical work of this bulletin both in the work in dilution and the other matters treated was done by Mr. Harry Snyder, assistant in chemistry and the work of setting, skimming and sampling was done by Mr. Clinton D. Smith, then assistant in agriculture here, now Director of the Minnesota experiment station.

The first trials were made on December 7th and 14th, with the mixed milk of the University herd. The milk was set in Cooley cans in a Cooley cabinet creamer, through which water just above the freezing point was constantly running. The results are given in Table I. In this and in all other cases of dilution the percentage of fat in the skim milk has been corrected for the amount of water added. That is, if the chemist reported .50 per cent. of fat in a sample of skim-milk to which fifty per cent. of water had been added, or which was two-thirds milk and one-third water, it would be equivalent to .75 per cent. of fat in the milk itself. This is what is meant by correction for water added and this correction must always be made in order to compare such a sample with one to which no water has been added.

TABLE I.

DATE.	No. of hours set.	Temp. water in tank.	Per cent. fat in whole milk.	Undiluted.			Diluted.					
				Lbs. milk.	Temp. set.	Per cent. fat in skim milk.	Lbs. milk.	Temp. milk.	Lbs. water added.	Temp. water added.	Temp. set.	Per cent. fat in skim milk.
Dec. 7	19	40	3.97	36	88	.48	24	88	12	134	102	.75
" 14	24	40	4.27	36	90	.49	24	90	12	134	104	.52
Aver.			4.12		89	.49				134	103	.64

Although the creaming is not quite so perfect as in most of the trials last summer, still there is no advantage from the dilution, in fact from the average of the two trials it was a decided disadvantage.

The next trials were made with the milk of five cows that had been longest in milk of any in the herd, it being expected that their milk being more difficult to cream would be more likely to show advantage from the addition of water. The cows and their milking periods were as follows :

Gem, thoroughbred Jersey, dropped calf March 4, 1890, bred Nov. 30, 1890, average daily yield for December, 14 pounds.

Glista, thoroughbred Holstein, dropped calf April 22, 1890, bred December 14, 1890, average daily yield for December, 14 pounds.

Beauty, high grade Jersey, dropped calf February 14, 1890, bred May 10th, 1890, average daily yield for December, 9 pounds.

Lil, native, dropped calf before February 15, 1890, not bred, average daily yield for December, 17 pounds.

Shadow, native, dropped calf before April 15, 1890, bred December 14, 1890, average daily milk yield for December, 20 pounds.

Of the mixed milk of these five cows a part was set without dilution and a part diluted. Both were set in Cooley cans under

the same conditions as in the trial in Table I, and the results are given in Table II.

TABLE II.

DATE.	No. of hours set.	Temp. water in tank.	Per cent. fat in whole milk.	Undiluted.			Diluted.					
				Lbs. milk.	Temp. set.	Per cent. fat in skim milk.	Lbs. milk.	Temp. of milk.	Lbs. of water added.	Temp. of water added.	Temp. set.	Per cent. fat in skim milk.
Dec. 15, P.M.	16	40	5.28	12	86	2.31	12	86	6	131	103	3.00
" 16, A.M.	14	40	5.55	24	81	2.60	16	82	8	130	98	3.11
" " P.M.	16	40	5.22	19	88	2.60	12	88	6	130	101	2.76
" 17 A.M.	24	40	5.80	23	86	2.05	16	86	8	126	98	2.31
Average			5.46		85	2.39		85		129	100	2.79

It was found that the milk from these cows was hard to cream, only slightly more than one-half of the fat being recovered, but it was not found that the addition of water was of any advantage as the average of four trials showed .40 per cent. more fat in the skim milk from the diluted lots than in the undiluted. The weather at the time this work was being done was cold, and the cows giving but small messes it was found to be almost impossible to milk the five cows, mix the milk and get it into the creamer before it had cooled down below ninety degrees, and to this we attributed in large measure our want of success. Accordingly another set of trials was made in which the milk both diluted and undiluted was heated up to 135° F. just before it was put in the creamer, the other conditions of creaming being the same as before. The results of creaming under this treatment are shown in Table III.

TABLE III.

DATE.	No. of hours set.	Temp. water in tank.	Per cent. of fat in whole milk.	Undiluted.			Diluted.					
				Lbs. milk.	Temp. set.	Per cent. of fat in skim milk.	Lbs. milk.	Temp. of milk.	Lbs. of water added.	Temp. of water added.	Temp. set.	Per cent. of fat in skim milk.
Dec. 17, P. M.	17	40	4.99	19	135	1.24	12	88	6	135	135	1.92
" 18, A. M.	27	40	5.25	24	135	1.40	14.5		7.25	135	135	1.80
" 18, P. M.	13	40	5.20	19	135	1.08	12		6	140	139	1.62
" 19, A. M.	13	40	5.55	22.5	135	1.58	16		8	135	135	1.95
Average			5.25		135	1.32				136	136	1.82

It will be seen that when the milk was heated up to 135° F. before setting, the creaming was considerably better than when it was set direct from the cow, but it was still much less complete than it should have been, and still the diluted milk showed the most fat in the skimmed milk. That the milk of these five cows should be so imperfectly creamed was very puzzling, especially as determinations showed that there was no greater proportion of lacto-fibrin present than in other samples that were very completely creamed. (See the article on the relation of fibrin to the effectual creaming of milk in another part of this bulletin.)

It was finally determined to try the effect on the creaming of this milk of mixing it with equal parts of milk from the general herd. For these trials the milk of only three of the cows, Glista, Gem and Shadow was used, as Lil had been sold and Beauty had gone dry. These trials were made of the milk of the three cows, and of the remainder of the herd simultaneously and then three trials were made of equal parts of milk of the three cows and of the remainder of the herd mixed. Because of the small amount given by the three cows it was not possible to make all three trials at the same time. The results are shown in Table IV.

TABLE IV.

Date.	MILK OF GLISTA, GEM, AND SHADOW.					
	No. hours set.	Temp. water in tank.	Lbs. milk.	Temp. set.	Per cent. fat in whole milk.	Per cent. fat in skim milk.
Jan. 22, 4 P. M....	17	40	19	88		1.02
Jan. 23, 7 A. M....	26	40	27	76	3.75	1.00
Jan. 23, 4 P. M....	17	40	19	90	5.00	1.55
Average				85	4.37	1.19
MIXED MILK. EQUAL PARTS OF MILK OF THE 3 COWS AND OF THE WHOLE HERD.						
Jan. 19, 4 P. M....	17	40	36	80		.38
Jan. 20, 5 A. M....	13	40	37	80	4.30	.65
Jan. 20, 4 P. M....	19	40	36		4.18	.45
Average				80	4.24	.49
MIXED MILK OF WHOLE HERD.						
Jan. 22, 4 P. M....	17	40	19	90		.38
Jan. 23, 7 A. M....	26	40	26	86	4.65	.30
Jan. 23, 4 P. M....	17	40	19	90	3.88	.30
Average				89	4.27	.33

It will be seen that while the milk of the three cows set separately was but slightly more efficiently creamed than it had been a month before, it was almost as completely creamed as the milk of the rest of the herd when it was mixed with equal parts of the milk of the rest of the herd. In other words while dilution with water did not in the least aid in the creaming of this obstinate milk, dilution with the milk of other cows made it almost as readily creamed as was the milk of the other cows. This opened up the very interesting question of the effect of one cow's milk on the creaming qualities of another's which we were prevented from pursuing further at the time but which we hope to make the basis of further investigations.

In addition to the experiments with dilution reported in newspaper bulletin No. 3 of the Vermont Experiment Station and quoted in our bulletin No. XX, the only reports of experiments on this subject which we have seen are found in bulletin No. 12

page 376 of the Illinois Experiment Station. It will be remembered that the Vermont Experiments showed a marked advantage from diluting the milk with warm water. The Illinois experiments were made with small quantities of milk (one quart) set in glass vessels three inches in diameter and eight inches deep. The only figures reported are as follows in percentages of fat in the skimmed milk.

	Undiluted.	Diluted with an equal volume of water.
Jersey cow.....	.93	1.21
Holstein cow.....	1.34	.60
Holstein cow.....	1.35	.45

Showing an advantage in diluting the Holstein milk and a disadvantage in diluting the Jersey milk. From the experiments as a whole the conclusions of Professors Morrow and Farrington are as follows: "These experiments do not make it probable that adding water to the milk is a desirable substitute for setting in cold or ice water."

In all of the trials we have made in diluting milk we have never received any advantage whatever from the water added, in fact all the cases but one the addition of water either hot or cold has been a distinct disadvantage. In one single case (the second trial in Table I this bulletin) the amount of fat in the skimmed milk was practically the same for both the diluted and undiluted samples.

Below we have grouped the results of all our experiments, including both those of this bulletin and those reported in bulletin XX, showing the average percentage of fat found in the skim milk under the various conditions. Of course in all cases of dilution, correction has been made for the amount of water added.

In sixteen trials where the milk was set in the Cooley creamer with ice water, at a temperature of 44°, the average per cent. of fat in the skim milk was.....	.28
In eleven trials where milk was diluted with an equal weight of cold water and set in the open air, the average per cent. of fat in the skim milk was.....	1.28
In six trials where milk was diluted with 20 and 50 per cent. of cold water and set in the open air and running water at 60°-63°, the average per cent. of fat in the skim milk was.....	1.24
In two trials where milk was diluted with 50 per cent. of hot water and set in Cooley creamer in	

ice water, the average per cent. of fat in the skim milk was.....	.64
In ten trials where milk was diluted with 10 to 100 per cent. of its weight of hot water, and set in the open air or running water at 59°-72°, the average per cent. of fat in the skim milk was.....	1.11
In two trials where milk was set in deep cans without dilution, in running water at 60°-63°, the average per cent. of fat in the skim milk was.....	.89
In two trials where milk was set in shallow pans, at 60°-64°, the average per cent. of fat in the skim-milk was.....	.46
In one trial where milk was set in shallow pans and one third of its weight of water at 120° added, the per cent. of fat in the skim milk was.....	.75
In eleven trials where milk of cows long in milk was set in Cooley cans in ice water, either direct from the cow or warmed to 135° the average per cent. of fat in the skim milk was.....	1.68
In eight trials where the milk of cows long in milk, either direct from the cow or warmed to 135° was diluted with 50 per cent. of water at 135° and set in Cooley cans in ice water, the average per cent. of fat in the skim milk was.....	2.31
In three trials where milk of cows long in milk was diluted with an equal weight of milk from the remainder of the herd and set in Cooley cans in ice water the average per cent. of fat in the skim-milk was.....	.49

THE EFFECT OF A DELAY IN SETTING ON THE EFFICIENCY OF CREAMING.

Our attention was drawn to this matter in the course of the experiments on dilution carried on in the summer of 1890. In those experiments on several occasions the milk set was what remained in the cans after going over the milk route, and we were considerably surprised to find that in general this milk was quite as efficiently creamed as that that was set direct from the cow, the figures being as follows on the average of several trials :

	Temp. set.	Per cent. of fat in skim milk.
Set direct, 4 trials.....	90	.23
Delayed 1½ hours, 6 trials	83	.25

It has been generally accepted as a fact that there is a considerable loss of fat when milk is allowed to stand for any length of time before setting and Henry found* from the result of churning tests that there was loss of butter fat of from 4 to 9 per cent., when the delay in setting was from 20 to 30 minutes. Our results were so at variance with the above that it seemed worth while to carry the investigation farther, accordingly the following additional trials have been made. The first trials were made on Dec. 7th and 14th from the mixed milk of the University herd. The milk was divided into three portions, one was set at once, one was delayed for an hour but kept up to a temperature of 92 in a water bath and the third was set in the open air and allowed to cool for an hour before set. In the cases of delay in this trial and all the succeeding ones the milk was stirred up just before it was placed in the creamer and all the settings were made in Cooley cans in ice water. The results are given in Table I.

TABLE I.

DATE.	No. hours set.	Temp. water in tank.	Per cent. fat in whole milk.	Set at once.			Delayed—kept warm.				Delayed—allowed to cool.			
				Lbs. milk.	Temp. set.	Per cent. fat in skim milk.	Lbs. milk.	Minutes delayed.	Temp. set.	Per cent. fat in skim milk.	Lbs. milk.	Minutes delayed.	Temp. set.	Per cent. fat in skim milk.
Dec. 7, P. M.	19	40	4.05	36	88	.48	36	60	92	.51	36	60	76	.71
Dec. 14, P. M.	24	40	4.40	36	90	.49	36	60	93	.68	36	60	80	.77
Average..	21	40	4.22		89	.49		60	93	.59		60	78	.74

In these two trials there was an average of .25 per cent. more fat in the skim milk from the delayed settings that were allowed to cool and .10 per cent. more fat in the skim milk from the delayed settings that were kept warm, than in the skim milk from the settings direct from the cow. Another and more extended trial was made somewhat later under the same conditions, the results of which are shown in table II.

*Second Report Wisconsin Agricultural Experiment Station p. 21.

TABLE II.

DATE.	No. hours set.	Temp. water in tank.	Per cent. fat in whole milk.	I. Set at once.		
				Lbs. milk.	Temp. set.	Per cent. fat in skim-milk.
1 Dec. 24 P. M.	13	40	3.90	35.5	92	.57
2 Dec. 25 A. M.	8.5	40	3.45	*18.5	86	.56
3 Dec. 25 P. M.	12	40	4.05	37	86	.59
4 Dec. 26 A. M.	9.75	40		29	88	.55
5 Dec. 26 P. M.	16	40	4.10	36	90	.24
6 Dec. 26 A. M.	8.25	40	4.15			
7 Dec. 26 P. M.	14	40	4.00			
8 Dec. 27 A. M.	9	40	3.90			
Average of all.	11	40	3.94		88	.50
Average No. 1-5....						.50

*4.40 fat in whole milk.

DATE.	II. Delayed—kept warm.				III. Delayed—cooled.			
	Lbs. milk.	Minutes delayed.	Temp. set.	Per cent. fat in skim milk.	Lbs. milk.	Minutes delayed.	Temp. set.	Per cent. fat in skim milk.
1 Dec. 24, P. M.	24.5	60	88	.59	*30	60	68	.64
2 Dec. 25, A. M.	†18.5	45	84	.56	75.5	220	62	.55
3 Dec. 25, P. M.	37	45	84	.47	61.5	60	74	.53
4 Dec. 26, A. M.	30 25	130	82	.68				
5 Dec. 26, P. M.	36	75	90	.22				
6 Dec. 26, A. M.	37.5	205	92	.68	37.5	205	58	.66
7 Dec. 26, P. M.	24	90	90	.49	23.5	90	65	.65
8 Dec. 27, A. M.	74	210	95	.68	74	210	64	.51
Average of all.		107	88	.55		141	65	.59
Average Nos. 1-5....				.50				.57
Average " 6-8....				.58				.60

*Four per cent. fat in whole milk set in air temp. 39°. †4.40 fat in whole milk.

In the above table the trials reported under the same number with the exception of the first and second are comparable as they were made from different portions of the same samples of milk. In numbers one to five inclusive the delayed sample (Column II) was kept warm in a water bath, in numbers six to eight the milk used had been carried about on the route and the delayed sample was heated up after having been allowed to cool.

It will be seen that in the average of the whole there is a very little more fat in the skim-milk where the setting was delayed, but it will be noticed that the delay was in many cases very long (2 to 3 hours) and it will also be noticed that this delayed milk was much more perfectly creamed than that of the five cows long in milk as given in tables II and III in the article on dilution. A churn test was made in connection with this experiment the results of which are given in table III. The cream from the settings of table II was divided into five churnings as follows :

1. Set direct, Table II, col. I, Nos. 1-5.
2. Delayed—kept warm, Table II, col. II, Nos. 1-5.
3. Delayed—allowed to cool, Table II, col. III, Nos. 1-3.
4. Carried on route, warmed to 90°, Table II, col. II, Nos. 6-8.
5. Carried on route, set without warming, Table II, col. III, Nos. 6-8.

TABLE III.

No.	Weight of milk.	Weight of butter.	Per cent. of fat		Lbs. of milk to one of butter.
	Lbs.	Lbs.	fat in butter.	in butter-milk.	
1	156.	7.56	86.86	.64	20.63*
2	146.25	6.94	87.52	.85	21.07
3	167.	7.94	87.05	.66	21.03
4	135.5	6.06	87.06	.74	22.30
5	135.	6.00	87.04		22.50

The slight increase in the number of pounds of milk required for one of butter in the delayed settings is more apparent than real, for it will be noticed that in all the delayed settings the percentages of fat in the butter and in the butter-milk both happen to be larger than in the settings that were made direct, and each of these would tend to require a larger number of pounds of milk for one

of butter. In other words the churn test is affected by and shows the error of both churning and creaming, while the analysis of the skim milk measures only the error of creaming.

In the latter part of March still another trial was made with delayed setting, the results of which are shown in Table IV.

TABLE IV.

DATE.	No. hours set.	Temp. water in tank.	Per cent. fat in whole milk.	Set at once.			Delayed—Cooled.			
				Lbs. milk.	Temp. set.	Per cent. fat in skim milk.	Lbs. milk.	Minutes delayed.	Temp. set.	Per cent. fat in skim milk.
Mar. 30, P. M.....	12	40	4.05				22	45	82	.63
" " " ".....			4.30				46	45	78	.53
" 31 A. M.....	10	40	4.40	34	86	.46	26	60	72	.61
" " P. M.....	15	40	4.30	36.5	89	.65	37	45	80	.58
Average.....	12	40	4.26		88	.56		50	78	.59

Churnings made from the cream of these settings gave the following results :

	Pounds milk.	Pounds butter.	Pounds of milk to one of butter.
From direct settings...	70.5	2.5	28.
From delayed settings	131	5.31	24.7

The analysis of the skim milk shows that in this trial there was practically no loss of fat from the delayed setting. The churn test gave better results from the delayed setting than from that set direct. This was in all probability due to errors in churning, but as the fat was not determined in the butter and buttermilk, no estimate could be made of the churning error.

Since the above was written there has been reported* the

*Report of the Maine Agricultural Experiment Station for 1890, part II, p. 46.

results of some experiments almost identical with those here reported, that were carried on by Professor Jordan of the Maine agricultural experiment station. The results briefly were as follows. Two series of trials were made ; in the first, one portion of milk was set at once and one portion after having been delayed was set in ice water without being disturbed. In the second trial the delayed portion was thoroughly stirred, as were ours, after the delay and before being submerged in the creamer. The following percentages of fat were found in the skim milk :

	Temp. set.	Per cent. of fat in skim milk.
1st trial, set at once, average of 9 settings	95	.29
1st trial, delayed, average of 9 settings	89	.32
2d trial, set at once, average of 5 settings	95	.24
2d trial, delayed, average of 5 settings	88	.26

In these trials the delay varied from one-half hour to one hour. It would seem that the conclusion from all these experiments must be that there is very slight danger of loss of fat in delaying the setting of milk for a considerable time after it is drawn, particularly if the temperature of the milk does not fall much below eighty degrees.

HENRY H. WING.

APPLICATION OF DR. BABCOCK'S CENTRIFUGAL METHOD TO THE ANALYSIS OF MILK, SKIM-MILK, BUTTERMILK AND BUTTER.

The analyses reported in the first article of this bulletin were all made by the gravimetric, asbestos method as described in bulletin XXV of this Station. Additional determinations were made of the fats by Dr. Babcock's centrifugal method, and of the total solids in both the whole and skim-milk, with the results given in the following tables.

TABLE I.

Whole milk.					Skimmilk.				
Laboratory number.	Fats.		Total solids.	Solids not fat.	Laboratory number.	Fats.		Total solids.	Total solids in excess of solids not fat in whole milk.
	By gravimetric.	By centrifugal.				By gravimetric.	By centrifugal.		
1402	4.00 3.93	3.90 3.90	13.14 13.03	9.10	1403	.75 .75	.75 .75	9.98	.88
					1404	.46 .49	.50 .60	9.96 10.00	.88
1405	4.15 4.17	4.10 4.10	13.43 13.45	9.28	1406	.54 .48	.50 .50	10.06 10.05	.78
					1407	.69 .74	.70 .65	10.02	.74
1408	4.25 4.29	4.20 4.25	13.26 13.24	8.98	1409	.49 .49	.60 .60		
					1410	.52 .52	.60 .67	9.69	.71
1411	4.53 4.54	4.40 4.50	13.98 14.08	9.50	1412	1.00 1.02	1.05 1.08	10.66	1.16
					1413	.76 .75	.70 .75	10.42	.92
1414	5.20 5.36	5.00 5.10	15.03 14.97	9.73	1415	2.41 2.35	2.50 2.50		
					1416	3.00 3.00	3.00 3.00	13.00	3.27
1417	5.50 5.60	5.60 5.50	15.32	9.77	1418	2.60	2.40	12.92	3.15
1419	5.22	5.35 5.35	15.08	9.86	1420	2.76 2.60	2.70 2.60	12.67 12.67	2.81
1421	4.40	4.40 4.40	14.08	9.68	1422	.64	.55 .60	10.32	.64
1423	3.45	3.45 3.45	12.66	9.21	1425	.55	.55 .50	9.67	.46

TABLE I. Continued.

Whole milk.					Skim milk.				
Laboratory number.	Fats.		Total solids.	Solids not fat.	Laboratory number.	Fat.		Total solids.	Total solids in excess of solids not fat in whole milk.
	By gravimetric.	By centrifugal.				By gravimetric.	By centrifugal.		
1426	4.05	4.00 4.05	13.55	9.50	1427	.53	.50 .50 .50	10.09	.59
1428	3.90	3.85 3.75	13.13	9.23	1429	.57	.45 .50 .50	10.10	.87
					1431	.56	.50 .50	10.36	.86
1430	4.00	4.00 4.05	13.55	9.50	1432	.56	.50 .60 .60	10.11	.61
1433	4.00	4.20 4.20	13.72	9.72	1434	.65	.60 .43 .50	10.43	.71
					1435	.49	.30 .30 .30	10.17	.45
1436	4.10	4.00 4.00	13.39	9.29	1437	.24	.25 .30 .30	9.63	.34
1439	3.90	3.90 3.90	13.07	9.17	1438	.22	.70 .60 .60	9.78	.39
1441	5.80	5.70 5.70	15.06	9.26	1440	.68	2.20 2.20		
1444	4.99	4.85 4.95	14.16	9.17	1442	2.05	1.50 1.60		
					1443	1.54 1.43			

TABLE II.

Whole milk.			Skim milk.		
No. of sample.	Fats.		No. of sample.	Fats.	
	Gravimetric.	Centrifugal.		Gravimetric.	Centrifugal.
1465	5.10	5.00	1456	.30	.25
1466	5.20	5.20	1458	.50	.50
1467	4.00	4.10	1459	.35	.40
1468	4.60	4.60	1460	.95	1.10
1469	4.90	5.00	1461	.40	.45
1470	4.20	4.20	1462	.30	.30
1472	6.40	6.40	1463	1.60	1.50
1473	4.00	3.85	1464	1.00	1.00
1474	4.50	4.40	1471	.70	.60
1475	6.00	6.00	1487	.51	.40
1476	4.45	4.45		.55	.40
1477	3.60	3.70	1488	.63	.60
1478	3.80	3.70			.60
1479	6.20	6.20	1489	.42	.40
1480	5.00	5.00			.40
1481	3.90	3.85	1490	.40	.46
1482	4.20	4.10	1492	.46	.50
1483	4.00	3.85		.45	.60
1484	4.60	4.60	1493	.61	.60
1486	4.00	4.00		.55	.60
	5.00	5.00	1494	.40	.40
			1495	.20	.20
			1496	.50	.40
			1497	.40	.35
			1498	.40	.40
			1499	.60	.65
			1500	.45	.40
			1501	.60	.60

TABLE III.

Butter.			Buttermilk.		
1445	87.26	86.85	1450	.53	.60
1446	87.19	87.85	1457	.48	.30
1447	87.00	86.72	1452	.46	.50
1448	87.00	87.04	1453	.45	.35
1449	87.21	86.91	1454	.51	.45
			1455	.46	.50

The average of the results of the hundred samples by the gravimetric method is 0.016 per cent. higher than by the centrifugal. This is of no significance ; although in the laboratory it is still a gain to use the gravimetric method when the solids are to be determined. In the case of skim-milk the determination of the fat by the gravimetric method is quite desirable, if not essential, especially in dilution experiments where corrections are necessary for the water added to the milk. In this case a slight error at first would be additionally increased. The method is equally applicable to cream, as has been shown by Mr. Winton, chemist to the Connecticut Experiment Station.

The centrifugal method is quick, accurate, and it takes but a short time to become acquainted with it ; it is applicable to milk, cream and butter, and reasonably so to skim-milk and buttermilk.

The total solids of the skim-milk consists of the solids not fat of the whole milk, and the fats left after skimming. The total solids of the skim-milk and the solids not fat of the whole milk, were determined, and the difference it would be supposed is due to the per cent. of fat in the skim-milk. The figures in Table I do not, on the whole, show a concordant agreement ; the fats by difference are somewhat in excess of the fats by determination. In the annual report (1890) of the Maine Experiment Station upon delayed setting of milk, all of the data are given for the fats by difference, as in Table I, except the column of fats by difference ; and a subtraction shows a similar higher result for the fats determined in this way.

From these facts it would appear that during the creaming process some slight change has taken place with relation to the solids, which later becomes apparent in the skim-milk.

HARRY SNYDER.

THE RELATION OF FIBRIN TO THE EFFECTUAL CREAMING OF MILK.

The announcement of fibrin in milk* offers a solution of many of the problems in dairying; and it has been claimed that the effectual creaming of milk is closely related to, if not dependent upon, the amount of fibrin present.

While the investigation recorded in the first part of this bulletin was in progress, it became evident that the creaming of the milk from some of the cows, that were near the close of their milking period, was very imperfect; analysis of the skim milk showed as high as three per cent. fat. The utmost care in setting, including a prolonged length of time before skimming, showed that the creaming was still very imperfect. This was supposed to be due to the amount of fibrin present.

Unfortunately there is no satisfactory quantitative method for its determination; and the only means of obtaining any idea of the amount to which it is present is by the volume of oxygen liberated, when the milk is treated with hydrogen peroxide. If the decomposition of hydrogen peroxide, is due only to the action of fibrin, it affords a satisfactory means for comparison.

The ordinary commercial hydrogen peroxide was first used but was found to be unsatisfactory, blank determinations showing that it would give up oxygen of its own accord. A much weaker solution was prepared by distillation in a vacuum, the solution as thus prepared was about five volumes strength; blank determinations showed a slight decomposition which never exceeded .1 c. c. for 10 c. c. of hydrogen peroxide.

The preliminary work consumed a great deal of time, and a portion of the first work had to be thrown out on account of the trouble with the hydrogen peroxide, and the length of time from milking until the determinations were made not being uniform. The apparatus used was an improved form of azotometer, devised by Prof. Caldwell, and it is so constructed as to admit of great precision in reading, and the errors of temperature variations are quite under control.

*Bulletin No. 18, Wisconsin Agricultural Experiment Station. Lacto-fibrin, a nitrogenous body found in milk analagous to fibrin in blood, which is supposed to coagulate milk, and keep the fat globules from coming to the surface.

For the determinations 10 c. c. each of milk and hydrogen peroxide were taken, shaken every five minutes for half an hour, and the necessary corrections made for temperature.

Duplicate determinations were made but occasionally the results were not concordant. The milk of the whole herd of some twenty cows was taken as a standard. The milk of Beauty was the most imperfect in creaming, the lot of three cows less so, and the mixed milk of the herd was about normal as to creaming.

The results are given in the following table :

DATE.	Kind of sample.	Fat in milk.	Fat in skim-milk.	Per cent. of volume of oxygen liberated.*
Jan. 15	Five cows	4.15	1.60	14
" 20	Three cows	4.05	1.40	9
" 20	Beauty	7.40	3.00	12
" 21	Herd	3.92	.60	8
" 21	Beauty	6.40	—	14
" 21	Three cows	4.45	1.50	12
" 22	Herd	3.75	.30	13
" 22	Beauty	6.00	—	10
" 22	Three cows	4.45	1.50	11
" 23	Herd	4.65	.35	13
" 23	Three cows	4.65	1.10	13
" 24	Herd	3.90	.30	12
" 24	Three cows	5.00	1.60	8
" 24	Beauty	6.20	—	11

*Supposed to be proportional to the amount of fibrin present.

SUMMARY.

From this table it appears that there is no definite relation between the amount of fat in the skim-milk, and the volume of oxygen liberated. The fat in the skim-milk is the measure of the efficiency of the creaming process; and the volume of oxygen liberated is supposed to be proportional to the amount of fibrin present; but the highest per centage of fat in the skim-milk is accompanied by as low a volume of oxygen as is the lowest per cent. It is evident that there are other factors of equal, if not of more importance than fibrin, that affected the creaming process of these samples.

In this investigation, the care of the milk, including the setting, skimming and sampling, was in charge of Mr. C. D. Smith, the present Director of the Minnesota Experiment Station.

HARRY SNYDER.

CORNELL UNIVERSITY

Agricultural Experiment Station.

BULLETIN 30.

HORTICULTURAL DIVISION.

AUGUST, 1891.

Some Preliminary Studies of the Influence of the Electric
Arc Lamp upon Greenhouse Plants.

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BULLETINS OF 1891.

26. Experiences with Egg Plants.
27. The Production and Care of Farm Manures.
28. Experiments in the Forcing of Tomatoes.
29. I. Cream Raising by Dilution.
II. The Effects of a Delay in Setting on the Efficiency of Creaming.
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IV. The Relation of Fibrin to the Effectual Creaming of Milk.
30. Some Preliminary Studies of the Influence of the Electric Arc Lamp upon Greenhouse Plants.

SOME PRELIMINARY STUDIES OF THE INFLUENCE OF THE ELECTRIC ARC LIGHT UPON GREENHOUSE PLANTS.

I. EXPERIMENTS AT CORNELL.

In the winter of 1889-90 we undertook experiments to determine what influence the ordinary street electric light exerts upon plants in greenhouses. Much has been said among gardeners concerning supposed retarding or accelerating influences of street lamps upon plants. Many have supposed that the electric light can be introduced profitably into greenhouses for the purpose of hastening growth. Still others have supposed the electric lights at exhibition halls to be injurious to plants, and have said that flowers fade quickly when placed near them. The whole subject of the relation of electric light to vegetation should be understood, and wholly aside from any thought of introducing the light into greenhouses, its influence upon plants, both under glass roofs and in the open, is a question which demands careful investigation.

For the purpose of our experiment, a forcing house 20x60 feet was set aside. The house is low, with a two-thirds span and a very flat roof ($22\frac{1}{2}^{\circ}$), and was designed for the growing of lettuce, radishes and cuttings. The house is ventilated entirely from the peak by small windows hinged at the ridge. It is heated by steam, the riser running overhead and the returns all lying under the benches. This house was divided into two nearly equal portions for our purpose by a tight board partition. One compartment was treated to ordinary conditions—sunlight by day and darkness by night—and the other had sunlight during the day and electric light during a part or whole of the night. In all the experiments the lamp was suspended from the peak of the house, the arc being $2\frac{1}{2}$ feet above the soil of the bench over which it was placed. The arrangement of the benches is shown in Fig. 1. The lower portion of the figure shows a cross section of the benches and walks ; 1, 2, 3 and 4 are the benches, and w,

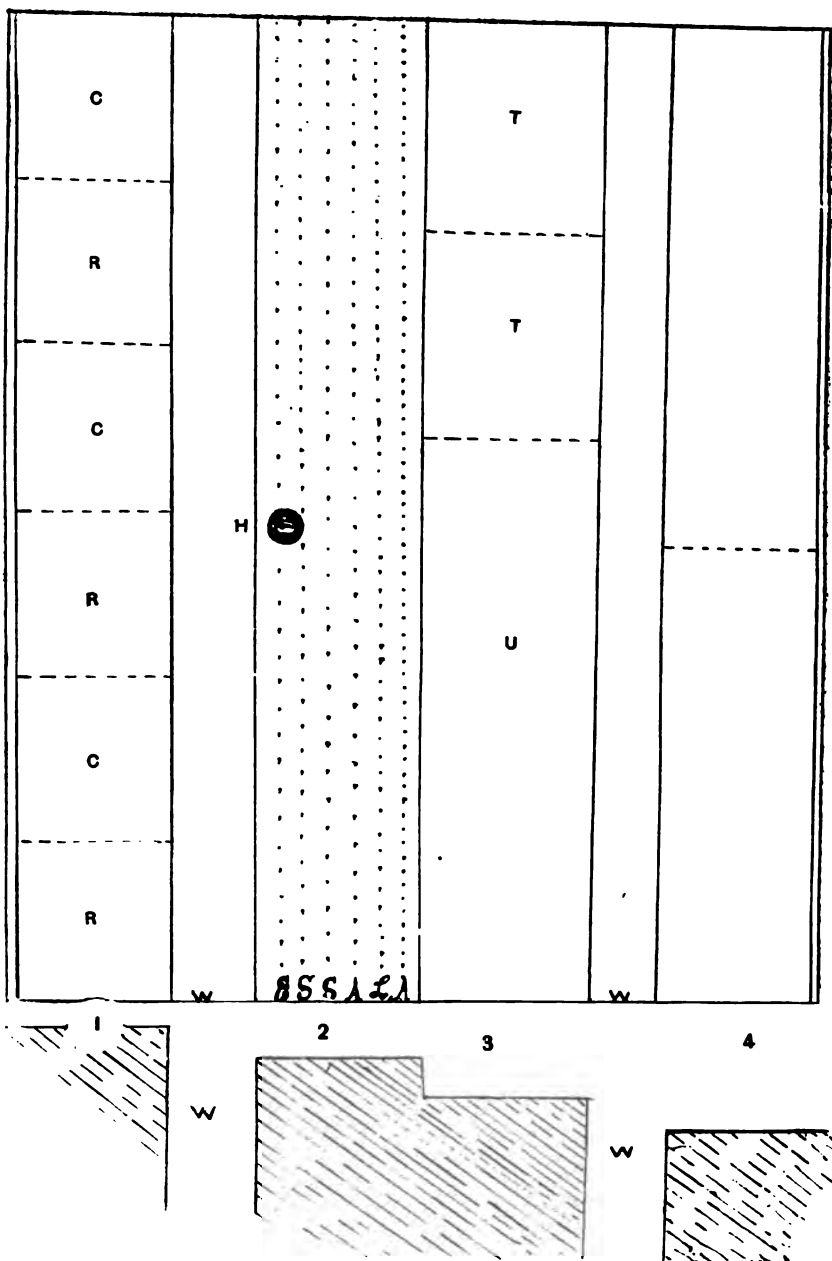


FIG. 1.—Plan of the Electric Light Compartment



Fig. 9. Bench of Lettuce in the Dark or Normal House.



Fig. 10. Bench of Lettuce in the Electric Light House.

Plate II.



*Fig. 2. Normal Spinage Plant ; Fig. 3 (to the right).
One of the same variety and age, from the light house.*



Fig. 7. Six best Tubers of Scarlet Frame Radish from Dark and Light Houses.

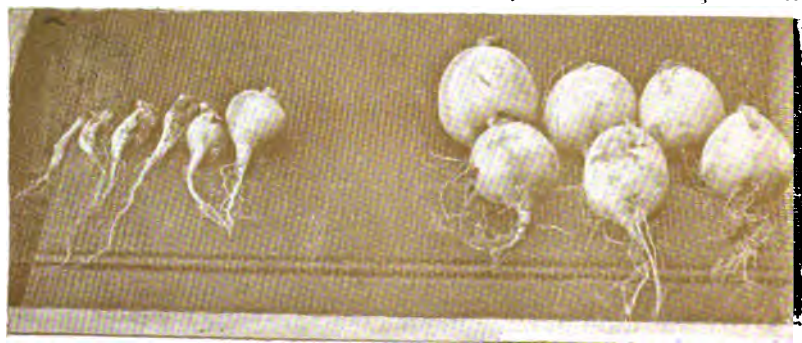


Fig. 8. Six best Tubers of White Box Radish from Light and Dark Houses.

w the walks. The outside benches, 1 and 4, are 4 ft. wide, and the middle ones $3\frac{1}{2}$ ft. wide. Bench 3 is nearly two ft. lower than No. 2. The upper portion of the figure shows a surface diagram of the house. The lamp is at H; 1, 2, 3, 4 show the benches, and w, w the walks. The arc was $9\frac{3}{4}$ ft. in a direct line from the edge of the lowest bench, 4, and $3\frac{1}{4}$ ft. from the edge of the highest bench, 1.

During the first winter (January to April, 1890) we used a 10 ampere, 45 volt, Brush arc lamp of 2000 nominal candle power. This was run all night—from dusk until daylight—from January 23d to April 12th. At first the light was started at 4:30 in the afternoon and ran until 7:30 in the morning, but as the season advanced the run was shortened until in April it ran from seven o'clock till five. For the first six weeks the light was naked, but during the remainder of the time an ordinary white opal globe was used. The cropping of the compartment, which was exactly duplicated in the other compartment, is indicated on the plan, Fig. 1. R, R, R, indicate spaces devoted to radishes, and C, C, C to carrots. In these instances the rows ran crosswise the bench. The bench directly under the light, No. 2, was planted, in rows running lengthwise, to endive, E, spinach, S, S, cress, A, A, and lettuce, L. Bench No. 3 was planted mostly to peas, U, in transverse rows, and two cutting frames, T, T, were placed upon it. The lowest bench, No. 4, was planted to lettuce, but the first crop was nearly mature when the experiment began and it was not taken into consideration.

1. *Experiments with a naked light running all night.*—(1890).

The general effect of the light was to greatly hasten maturity, and the nearer the plants grew to the light the greater was the acceleration. This tendency was particularly marked in the leaf-plants—endive, spinach, cress and lettuce. The plants “ran to seed” before edible leaves were formed, and near the light the leaves were small and curled. This is well illustrated in spinach, Figs. 2 and 3, plate II. The cuts, which are made to the same scale, show Round Dutch spinach when seven weeks old. Fig. 2 shows an average plant from the dark or normal house, and Fig. 3 one from the light house within 7 ft. of the lamp.*

*All distances from the lamp are measured in a direct air line from the arc.

The electric light spinage matured and produced good seeds while that in the dark house was still making large and edible leaves with no indication of running to seed. An examination under the microscope of leaves of the plants illustrated in Figs. 2 and 3 showed that while there was apparently the same amount of starch in each, it was much more developed in the electric light specimen, the grains being larger and having more distinct markings and giving a better color test when treated with iodine.

Fig. 4, shows two representative plants of Prickly Seeded spinage at four weeks of age. The one at the left grew in the dark house, and it is making a normal, spreading growth. The other grew in the

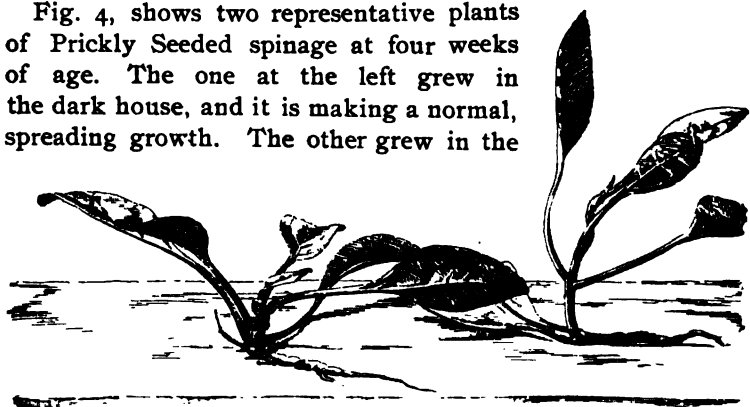


FIG. 4.—*Spinage Plants at Four Weeks of Age.*

light house, and the plant is sending up a central stem preparatory to flowering, and the leaves are smaller than in the other. Landreth's Forcing lettuce, growing in a row nearly under the lamp (L, Fig. 1) behaved in a similar manner. For three feet either side of the lamp, most of the plants were killed outright soon after they came up, and the remaining ones in the entire row (35 plants) were seriously injured, the leaves curling and remaining very small. The plants increased in stature, vigor and size of leaves with increased distance from the lamp. Those nearest the lamp made most leaves early in their growth, and they maintained this advantage until about four weeks old, although the leaves were smaller. Five weeks after sowing, the average height of plants within four feet of the lamp was 1.2 in.; between four and five feet, 1.34 in.; between five and six ft., 1.8 in.; between six and seven ft., 2 in.; between seven and eight ft., 2.2 in. The average height of plants in the dark house at this time was $2\frac{1}{4}$ in., and the plants were much more vigorous and

had larger and darker leaves. The increase in size was not uniform with increase in distance from the lamp. There were somewhat regular alternations of lower and higher plants, although there was a general progression in height. This is shown in the diagram, Fig. 5, in which each bar represents a plant one-sixteenth full size. The upper series represents those plants lying to

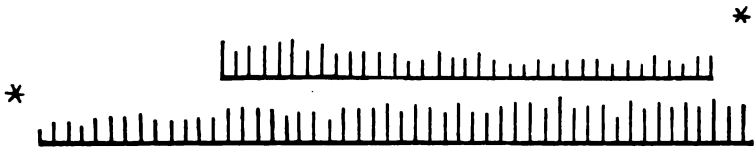


FIG. 5.—*Growth of Lettuce.*

the left of the light, and the lower one those lying to the right. This alternating elevation and depression is perhaps due to the concentric bands of varying intensity of light which fall from the arc and which are caused by the uneven burning of the carbons.



FIG. 6.—*Endive in Shadow and Full Light.*

Two varieties of cress (the French *cresson alénois* and *C. alénois frist*, *Lepidium sativum*), which were grown almost directly under the light, behaved in the same way as the spinach and lettuce. For five feet either side of the light the plants died soon after coming up; and seven weeks after sowing all surviving plants in the light house, excepting a few which were shaded, were in bloom, and all were small and the leaves were curled. Those in the dark house at the same time were strong and vigorous, with good leaves and no blossoms.

Endive gave the same results. It chanced that for a time two rows of endive grew parallel to each other in the light house, but one stood in full light while the other was shaded by an iron post an inch and a half in diameter. The result is well shown in Fig. 6, page 89. The row to the left was shaded, and the other received the full light. There was great difference between the two rows. The following figures show the weights of the individual plants in both rows after having grown two months in the light, at the given distances :

In full light.			In shade of post.		
Plant.	Distance from lamp.	Weight.	Plant.	Distance from lamp.	Weight.
No. 1	4 ft. 4½ in.	9 grains.	No. 1 a	4 ft. 8 in.	138 grains.
" 2	5 ft.	16 "	" 2 a	5 ft. 4½ in.	57 "
" 3	5 ft. 9½ in.	27 "	" 3 a	6 ft.	130 "
" 4	6 ft. 5½ in.	26 "	" 4 a	7 ft. 5 in.	158 "
" 5	7 ft. 2½ in.	72 "	" 5 a	8 ft. 4 in.	33 "
" 6	8 ft.	67 "	" 6 a	9 ft. 2 in.	47 "
" 7	8 ft. 9 in.	96 "			
" 8	9 ft. 6 in.	84 "			
Average		49.6 grains.			93.8 grains.

An average plant in the dark house of the same age weighed 575 grains, and it was larger leaved and darker colored than those grown in the other compartment.

These figures show at once the damaging influence of the naked electric light upon plants near it. Not only were the plants in direct light smaller than those in shadow, but the weight and the vigor of plants in light increased rapidly as distance from the light became greater, while those in shade were heaviest near the light where the shadow was most dense.

Some of the most marked results in this first series of experiments were obtained with the radishes on the highest bench (No. 1, Fig. 1). The young radish plants were strongly attracted by the light, and in the morning they all leaned at an angle of from 60° to 45° towards the lamp. During the day they would

straighten up, only to reach for the lamp again on the succeeding night. This was repeated until the roots began to swell and the plant became stiff. As the plants grew, the foliage became much curled, and the amount of this injury was in direct proportion to the nearness to the lamp. Those nearest the lamp—within three to six feet—were nearly dead at the expiration of six weeks, while those 14 ft. away showed little injury to the leaves. The following are figures of weights and sizes of radishes in the two houses :*

VARIETY.	Average weight of entire plant.		Average weight of top.		Average weight of tubers.		No. of marketable tubers.	
	Light house.	Dark house.	Light house.	Dark house.	Light house.	Dark house.	Light house.	Dark house.
Cardinal Globe . .	.14 oz.	.17 oz.	.08 oz.	.08 oz.	.059 oz.	.089 oz.	55 pct.	62 pct.
Dreer Scar't Frame	.067 "	.14 "	.036 "	.057 "	.031 "	.083 "	30 "	74 "
White Box.	.23 "	.43 "	.048 "	.21 "	.082 "	.22 "	6 "	75 "
	.27 "	.50 "	.16 "	.23 "	.11 "	.27 "	18 "	100 "
Average	.18 oz.	.31 oz.	.08 oz.	.14 oz.	.07 oz.	.16 oz.	27 pct.	78 pct.

The table shows that the crops obtained in the dark or normal house were about twice greater than those in the light compartment. The entire plants and the tops were almost half lighter in the light house, and the tubers were more than half lighter, while the per cent. of tubers large enough for market, was as 9 in the light house to 26 in the dark house. And it should also be said that the average size of the tubers graded as marketable was less in the light house than in the other. This is well shown in Fig. 7, plate II, which represents the six best tubers of Dreer Scarlet Frame from the dark house upon the left, and the six best from the light compartment upon the right. A portion of the plantation of White Box radish in the light house—occupying the uppermost radish plot on bench No. 1 (see Fig. 1)—was protected by the fan-shaped shadow cast by an iron post an inch and a half

*The figures were made from the entire crop when the plants in the dark house gave the first good market picking, and this accounts for the small per cent. of marketable tubers in the table ; but the plants in both houses were the same age.

in diameter. In the shadow the foliage was scarcely injured, while those leaves which projected into the light were curled. The following measures of these plants are instructive :

SAMPLES.	Average weight of entire plant.	Average weight of tops.	Average weight of tubers.	No. of marketable tubers.
Light house, in full light	.11 oz.	.09 oz.	.02 oz.	0
“ “ shadow	.35 “	.21 “	.14 “	45 pct.
Dark house.....	.43 “	.21 “	.22 “	75 “

This variety stood near the light, ranging from four to nine feet away. The contrasts between the two houses were also very great. Fig. 8 shows upon the left the six best radishes from the light and upon the right the six best from the dark house.

A chemical analysis of samples of these radishes from the light house, in both full light and shadow, and the dark house, gave the following results :

SAMPLES.	Ash.	Potash K ₂ O.	Chloro- phyll.	Total nitro- gen.	Albumi- noid ni- trogen.	Amide nitro- gen.	Albumi- noids. (Albu- minoid N. x 6.25.)
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
Lighthouse, full light	3.84	0.38	6.22	1.36	1.24	.12	7.75
“ in shadow	3.76	0.34	6.12	1.38	1.20	.12	7.50
Dark house.....	3.26	0.15	5.02	1.34	1.01	.33	6.31

These figures show that the plants under the electric light had reached a greater degree of maturity than those in the normal or dark house. The ash is more, potash more than double, and chlorophyll (including extracted gums) somewhat more. The total nitrogen is essentially the same in all samples, but it is noticeable that in the electric light plants more of the amide nitrogen has been changed into other forms than in the other sample ; and the electric light samples are richer in albuminoids. The light house plants from the shadow are much nearer to those in full light in composition than to those in the dark house.

Dwarf peas were grown in transverse rows upon bench No. 3, (U, Fig. 1). This bench is so low that No. 2 shaded about half of it. In the shaded portion the peas were larger and more pro-

ductive than those in full light, although the latter were farther from the lamp. The average heights of plants were as follows :

Light house, in full light, 4.8 inches. Light house, in shade, 5.3 inches.

Dark house, 5.8 inches.

The plants in the light house, particularly those in direct light, blossomed about a week in advance of those in the dark house, and they gave earlier fruits, but the productiveness was less, being in the ratio of 4 in the light house to 7 in the dark house. The decrease in production was due largely to the fewer number of peas in each pod, for the number of fruitful pods produced in each case was as 7 in the light house to 9 in the dark house, and there were many seedless pods in the light house. In other words, the production of pods (or flowers) was about the same in both houses, but the plants in the light house produced only four-sevenths as many seeds as those in the dark compartment.

It is apparent from the above experiences that the plants in the electric light house were injured. The question at once arose whether the injury was due to the electric light itself or to continuous light during the whole twenty-four hours. To test this point, 10-inch pots were inverted over radish plants during the day and removed at night, so that the plants received no sunlight and about 12 hours of electric light. Rubber tubing was conducted underneath the pots and was connected with the hole in the bottoms in such a manner that perfect ventilation was secured and yet no light admitted. Seedling radishes, which had never received sunlight, made a slender and sickly growth, assuming a faint green color, but died in three or four weeks.

The experiment was now conducted upon a larger scale, and at a time when the hours of sunlight were about equal to the hours of electric light. A tight wooden frame was placed upon the soil of a bench at one end of the light house. This frame was provided with a tight cover which was kept on during the day and removed at night. Feb. 1st radish seeds were planted in this frame both in the soil and in pots. The plants appeared on the 5th, and for several days grew very rapidly, making a spindling and nearly colorless growth. They were shaded by the side of the box and received only diffused light. On the 11th, some of them measured 4 inches to the leaves and 6 inches in total

height. On the 12th they looked yellow and seemed to be failing. Feb. 21st they began to die, and they were all dead on the 28th. On the 8th of February radish seeds were sown in pots and these were elevated in the frame so that the young plants received direct light. The plants were up on the 11th. They behaved the same as those in diffused light, and all were dead March 3d. None of the radish plants in the entire experiment succeeded in making a third or true leaf.

Strong lettuce plants were set in the frame in diffused light, but all died in about two weeks. Beans were planted Feb. 3d in diffused light. The plants appeared on the 10th. On the 25th growth had ceased, and the stems were 10 to 12 inches high, slender and light colored. They were all dead March 13th. The second pair of true leaves appeared, but did not develop. Corn planted at the same time had grown 12 inches tall by Feb. 25th, and was dead Mar. 7th. Potato tubers planted Feb. 5th made a spindling growth and reached the top of the frame (somewhat over a foot) March 13th. The stems then fell over because of their weakness and grew about the bottom of the frame. April 3d the stems were nearly four feet in length, very spindling, and bore a few small and pale leaves. A small and healthy castor bean plant chanced to be growing on the bench when the frame was placed in position. This was covered by the frame Feb. 1st, and in two weeks, having received only electric light, it was dead.

Another series of tests was made by covering well established plants in the beds. A tight box 18 inches square and a foot high was placed over certain plants during the daytime, and was removed at night and placed over contiguous plants of the same kind. Thus one set of plants received only electric light and one only sunlight, and inasmuch as both were covered during half of the twenty-four hours, any error which might have arisen from the covering itself — as lack of ventilation and increased heat — was eliminated. Feb. 7th certain radishes in the light house which had been planted two weeks were covered. In eight days some of the plants which were covered during the day were dead and the remaining ones were very weak. At the same time, those which were covered during the night had made a better growth than they had before and better than contiguous

plants which had not been covered. An examination of the leaves of the plants receiving only the electric light showed that they contained no starch and very little or no chlorophyll. Feb. 8th two lots of beans and radishes were planted in pots sunk to their brims in the soil between the radish rows in the light house. One lot was covered during the day and the other during the night, as above. Germination was the same in both lots. Feb. 25th, the daylight beans had made a stocky growth of $3\frac{1}{2}$ to 4 inches, while the electric light lot had made a weak growth of 8 to 9 inches. Radishes behaved in a similar manner. March 3d the leaves of the electric light beans began to wither, and both beans and radishes were dead Mar. 10th. The daylight lots continued to grow thriftily.

On Feb. 15 two strong plants of German ivy (*Senecio scandens*), carnation and begonia were selected for a similar experiment. One plant of each was covered by day and the other by night. Feb. 28th the electric light ivy appeared as if dying, and Mar. 10th it was apparently dead. By Mar. 3d the electric light carnation was seen to be making an etiolated growth. A month later the new white growth had become 4 to 6 inches long. The electric light begonia began to drop its leaves Mar. 5th, and a month later all the leaves had fallen. Another begonia, which chanced to be standing in diffused electric light, did not lose its leaves. By the middle of March the ivy threw up a shoot from the root, but the sprout remained feeble. April 3d the boxes were removed entirely from both lots. The contrasts were most striking. The daylight plants were strong and dark colored, while the others were dead or nearly so. From that time until the close of the experiment for the season, Apr. 12th, all the plants had the same conditions,—daylight, and electric light at night. A week after the experiment had closed and the electric light had been stopped, the begonia began to send out new leaves, the new shoot on the ivy began to assume a natural color and habit, but the carnation plant was nearly dead and apparently past recovery.

Peas were also treated in a similar manner. A row of peas which had grown for a month in direct electric light and which was in ordinary health, was divided into two equal parts and covered. In 14 days a part of the electric light lot was dead, and the

others were rapidly dwindling, while the daylight plants had improved. At this time the boxes were permanently removed, but the remaining electric light plants did not recover, and soon died.

The above experiments show conclusively that within the range of an ordinary forcing-house the naked arc light running continuously through the night is injurious to some plants ; and in no case did we find it to be profitable. But the fact that the light hastens maturity or seed bearing suggests that a modified light may be useful under certain conditions. Our next step, therefore, was to temper the light by the use of a globe.

2. Experiments with a protected light running all night.—(1890.)

Early in March, 1890, an ordinary white opal globe was placed upon the lamp, and for five weeks experiments similar to those already described were conducted. The effect of the modified light was much less marked than that of the naked light. Spinage showed the same tendency to run to seed, but to a much less extent, and the plants were not affected by proximity to the lamp. Lettuce, however, was decidedly better in the electric light house. Radishes were thrifty in the light house, and the leaves did not curl, but they produced less than in the dark house, although the differences were much less marked than in the former experiments. These second series of experiments can scarcely be compared with the former ones, because of the greater amount of sunlight which the plants received in the lengthening days of spring. The figures obtained from radishes, however, may afford a practically accurate comparison because of their rapid growth. The following table should be compared with that on page 91 :

VARIETY.	Average weight of entire plant.		Average weight of top.		Avg. weight of tubers.		No. of marketable tubers.	
	Light house.	Dark house.	Light house.	Dark house.	Light house.	Dark house.	Light house.	Dark house.
Half-long Rose . .	.41 oz.	.41 oz.	.19 oz.	.16 oz.	.22 oz.	.25 oz.	84 pct.	97 pct.
Scarlet Globe . .	.26 "	.34 "	.12 "	.14 "	.14 "	.20 "	76 "	87 "
Prussian Turnip . .	.24 "	.26 "	.08 "	.08 "	.16 "	.18 "	88 "	95 "
Blood-red . .	.28 "	.29 "	.11 "	.09 "	.17 "	.20 "	100 "	100 "
French Breakfast.	.27 "	.33 "	.09 "	.08 "	.18 "	.25 "	90 "	100 "
Half-long Scarlet..	.36 "	.40 "	.14 "	.15 "	.22 "	.25 "	90 "	75 "
	.25 "	.30 "	.13 "	.11 "	.12 "	.19 "	100 "	100 "
	.22 "	.32 "	.08 "	.08 "	.14 "	.24 "	85 "	100 "
Average	.29 oz.	.33 oz.	.12 oz.	.11 oz.	.17 oz.	.22 oz.	89 pct.	94 pct.

The loss due to the electric light averages from one to five per cent. in the different comparisons, while the loss occasioned by the naked light (see page 91), was from 45 to 65 per cent. It is noticeable, also, that while the tops or leaves were lighter under the naked light, they were heavier under the modified light than those of normal plants; and this is interesting in connection with the fact that lettuce did better under the modified light than in the dark house. The carrots (Short-horn Scarlet, C, C, C, Fig. 1) gave indifferent results. They did not appear to be affected greatly even by the naked light, even when growing directly opposite to it and but three or four feet away. Carrots require such a long period of growth that the first good picking was not obtained until the end of the experiment in April. The plants therefore grew under both the naked and protected lamps. In the following calculation the plat on the upper or east end (see Fig. 1) is omitted because it appeared to have been modified somewhat by the greater heat occasioned by the elbows in the steam pipes at that point:

SAMPLES. (Carrot).	Average weight of entire plant.	Average weight of tops.	Average weight of tubers.	No of marketable tubers.
Light house, center	.14 oz.	.08 oz.	.06 oz.	51 per ct.
" west end	.16 "	.08 "	.08 "	63 "
Dark house.....	.19 "	.11 "	.08 "	64 "

The figures show that the plants which grew directly in front of the lamp were but little inferior to those which stood 10 or 12 feet away, or even to those in the dark house. No other plant in our experiments has withstood the electric light so well.

Observations were made towards the close of the experiment upon the influence of the light on the blooming of plants, but the subjects were not numerous enough to enable us to draw definite conclusions. There was little difference in the length of time which flowers lasted in the two compartments. Flowers of primula and cineraria appeared to last longer by a day or so in the light house, while begonia and zonal geranium persisted rather longer in the dark house. These may have been incidental variations, and the subject was subsequently more fully investigated, as will appear in the sequel.

We had now found that the injurious effects of the electric lamp are lessened by the use of a thin globe, probably because glass cuts off the highly refrangible and invisible rays. The globe distributes the luminous rays more evenly, and probably absorbs a few of them, but the injury was lessened to an extent out of all proportion to the amount of modification in light; and we had found that lettuce and the leaves of radishes had grown larger under the light than in ordinary conditions. These facts indicate that there may be conditions under which the electric light can be made profitable to the gardener, and they suggested the experiments of the succeeding winter; and here the investigations for 1890 closed.

3. *Experiments with the naked light running a part of the night.*
—(1891.)

From January 16th to May 1st, 1891, the experiment was conducted under new conditions. The arrangement of the house or compartments remained as before, but the lamp was connected with a street lighting system and the light ran but a few hours, and never on moonlight nights. In this test we used a 10 ampere 45 volt 2000 nominal candle power Westinghouse alternating current lamp. Radishes were grown upon bench No. 1 (see Fig. 1), peas upon No. 3 and lettuce upon the lowest one, No. 4. Upon bench No. 2, nearest the lamp, a variety of ornamental plants was grown, mostly tulips, verbenas, petunias, primulas, heli-

trope and coleus. These ornamentals were mostly named one-colored varieties, and they were grown to enable us to make observations concerning the influence of electric light upon color. In this experiment, the lighting of the compartments was reversed during the last month, in order to eliminate any error which might arise from any minor differences in the temperature or other conditions of the two portions of the house. In order to properly understand the significance of the observations which follow, the reader will need to consult the following record of the dates and hours of lighting :

DATES.	Light ran from	No of hours run.	DATES.	Light ran from	No. of hours run.
Jan. 16	5 to 7 P. M.	2	Mar. 11	6 to 11	5
" 17	5 to 6	1	" 12	6 to 11	5
" 18	o	0	" 13	6 to 11	5
" 19	5 to 7	2	" 14	7 to 11	4
" 20	5 to 7	2	" 15	o	0
" 21	o	0	" 16	o	0
" 22	5 to 8	3	" 17	o	0
" 23	5 to 7	2	" 18	o	0
" 24	5 to 6	1	" 19	o	0
" 25	o	0	" 20	o	0
" 26	5 to 10	5	" 21	o	0
" 27	5 to 10	5	" 22	o	0
" 28	o	0	" 23	o	0
" 29	5 to 11	6	" 24	o	0
" 30	5 to 6 A. M.	13	" 25	o	0
" 31	5 to 11	6	" 26	7 to 8	1
Feb. 1	5:30 to 11	5½	" 27	7 to 8	1
" 2	5:30 to 11	5½	" 28	7 to 11	4
" 3	5:30 to 11	5½	" 29	7 to 11	4
" 4	5 to 11	6	" 30	7 to 11	4
" 5	5 to 11	6	" 31	7 to 11	4
" 6	5 to 11	6	Apr. 1	7 to 11	4
" 7	5:30 to 11	5½	" 2	7 to 11	4
" 8	5:30 to 11	5½	" 3	7 to 11	4
" 9	5 to 11	6	" 4	7 to 11	4
" 10	5 to 11	6	" 5	7 to 11	4
" 11	5 to 11	6	" 6	7 to 11	4
" 12	5:15 to 11	5¾	" 7	7 to 11	4
" 13	5 to 11	6	" 8	7:30 to 11	3½
" 14	5:15 to 6	¾	" 9	7:30 to 11	3½
" 15	o	0	" 10	7:30 to 11	3½
" 16	5:15 to 8	2¾	" 11	7:30 to 11	3½
" 17	5:15 to 8	2¾	" 12	7:30 to 11	3½
" 18	5:15 to 8:30	3¼	" 13	o	0
" 19	6 to 8:30	2½	" 14	o	0
" 20	5:30 to 8:30	3	" 15	o	0
" 21	5:30 to 8	2½	" 16	o	0
" 22	o	0	" 17	o	0
" 23	6 to 7	1	" 18	o	0
" 24	5:30 to 8	2½	" 19	o	0
" 25	5:30 to 8:30	3	" 20	o	0
" 26	5:30 to 8:30	3	" 21	o	0
" 27	5:30 to 11	5½	" 22	o	0
" 28	6 to 11	5	" 23	o	0
Mar. 1	6 to 11	5	" 24	7:30 to 12	4½
" 2	6 to 11	5	" 25	8 to 10:30	2½
" 3	6 to 11	5	" 26	7:30 to 11	3½
" 4	6 to 11	5	" 27	8 to 11	3
" 5	6 to 11	5	" 28	8 to 11	3
" 6	6 to 5 A. M.	11	" 29	8 to 11	3
" 7	6 to 11	5	" 30	8 to 11	3
" 8	6 to 11	5	May 1	8 to 11	3
" 9	6 to 11	5			
" 10	6 to 11	5			
			Total.....		308 hours.

Of radishes, the White Box and Cardinal Globe were grown. The foliage was noticeably larger in the electric light house, as it had been under the modified light (see page 97), but the tubers were practically the same in both houses, and the date of maturity was the same. Notwithstanding its greater size, the foliage in the light house showed some signs of curling.

American Wonder and Advance peas were grown, and in every case they were larger and more fruitful in the dark house. The electric light did not increase the size of leaves, as it did in the radishes. These results are similar to those obtained in 1890.

The lettuce, however, was greatly benefitted by the electric light. We had found that under the protected light (see page 96) the lettuce had made a better growth than in normal conditions, but now it showed still greater difference. Lettuce of two varieties—Landreth Forcing and Tennis Ball or Boston Market—was transplanted onto bench No. 4 when the light started. Both varieties were planted in each house, and the plants were all alike; and all the conditions in the two compartments were kept as nearly alike as possible. Three weeks after transplanting (Feb. 5), both varieties in the light house were fully 50 per cent. in advance of those in the dark house in size, and the color and other characters of the plants were fully as good. The plants had received at this time $70\frac{1}{2}$ hours of electric light. Just a month later the first heads were sold from the light house, but it was six weeks later when the first heads were sold from the dark house. In other words, the electric light plants were two weeks ahead of the others. This gain had been purchased by $161\frac{3}{4}$ hours of electric light, worth at current prices of street lighting about \$7.00.

This lettuce test was repeated and was watched very closely when the lamp was transferred to the compartment which had formerly been kept under normal conditions. The same results were obtained, and the differences in the two crops were so marked as to arrest the attention of every visitor. The electric light plants were in every way as good in quality as those grown in the dark house; in fact, the two could not be told apart except for their different sizes. Figs. 9 and 10, plate I, show representative portions of the crops as they appeared five weeks after being transplanted to permanent quarters. Fig. 9 is a view in the dark

house, and Fig. 10 in the light house. The variety in this case is Landreth Forcing. The history of the plants is as follows: The seeds were sown in flats Feb. 24th. Until March 17th they were grown under ordinary conditions, at which time they were set in their permanent positions in the two compartments. We began to pick lettuce from the light house April 30th, but the first of equal size from the dark house was obtained May 10th. The electric light plants were therefore upon the benches 44 days before the first heads were sold. During this time there were 20 nights in which the light did not run, and there had been but 84 hours of electric light, worth about \$3.50. In order to compute the cost of growing lettuce by the aid of the electric light, it is necessary to know how far the influence of the light will extend. This we do not know; but the lamp exerted this influence throughout a house 20x30, and the results were as well marked in the most remote part as they were near the lamp.

The results obtained from lettuce suggest many questions, all of which must be answered by experiment. We need to know if there is any particular time in the life of the lettuce plant when the light has a predominating influence; if a mild light is as good as a strong one; if the failure of the light during the moonlight nights is a serious drawback; to what distance the influence of the light extends; if the same results can be obtained by hanging the lamp over the house, instead of inside it, and by that means lighting several houses at once; if other plants can be profitably forced by means of electric light. In all these directions, and many others, we are planning experiments for the coming years.

The influence of the light upon productiveness and color of flowers was found to vary with different species and different colors within the same species. Several named varieties of tulips gave interesting results. Careful observations were made upon Proserpine, light cherry color; Wourseman, maroon; Vander Neer, light cherry; Yellow Pottebakker, bright yellow; Belle Alliance, scarlet; and Cerise gris delin, cherry and white. Upon the 13th of February, when these came into full flower, it was found that in every case the colors were deeper and richer in the light house; but the colors lost their intensity after four or five days and were indistinguishable from those in the dark house.

The plants in the light compartment had longer stems and larger leaves than the others ; and there was a greater number of floriferous plants in the light. The tulips were grown at a distance of 10 and 12 feet from the lamp.

Verbena flowers near the light were uniformly injured. February 26th, all plants within six feet of the light were stunted, the leaves were small and curled, and the flowers were short lived. The flowers were small, and those on the lower part of the clusters turned brown and died before those on the top opened. The buds within two or three feet of the lamp curled up and shrunk and became discolored before opening, but the discoloration did not extend to the inside of the flower until it had opened. Scarlet, dark red, blue and pink flowers within three feet of the light soon turned to a grayish-white, and this discoloration was noticeable to a

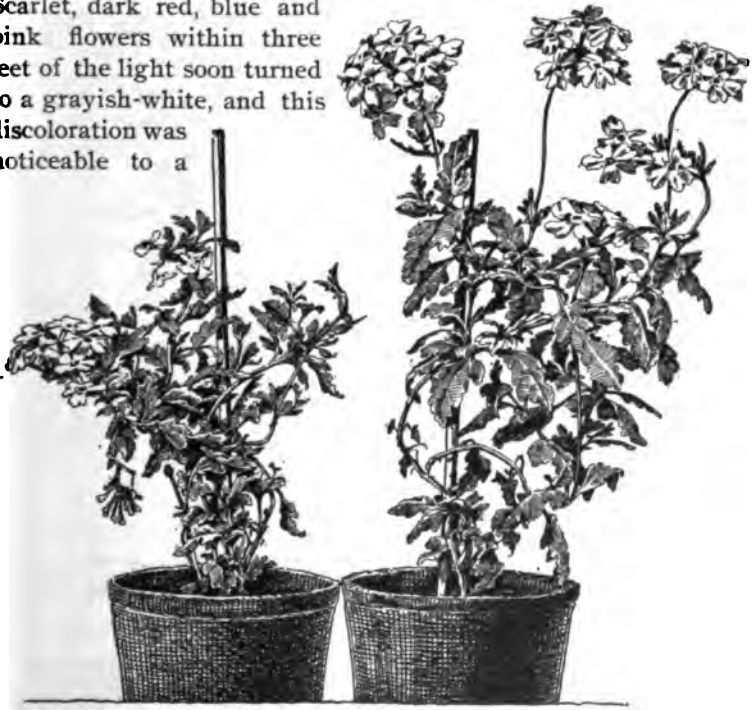


Fig. 11.—Influence of Electric Light upon Verbenas.

distance of six and seven feet. The plants bloomed somewhat earlier in the light house than in the other. Figs. 11 and 12 show the influence of the electric light upon verbenas. The left speci-

men in each instance stood four feet from the lamp, and the right hand specimen is from the dark house. The two light house specimens show the way in which different individuals are affected by the light. In Fig. 11 — which shows a white-flowered variety — the electric light specimen is much dwarfed and weak



Fig. 12.—Influence of Electric Light upon Verbenas.

and it could not stand alone. It is nearly past flowering, while its companion is in good condition. Fig. 12 shows a red variety. The electric light plant in this case grew taller and was stronger, but it did not reach the stature of its neighbor from the dark house, and its flowers have all disappeared and the flower stems have broken off while the other is in its prime. At a distance of 9 and 10 feet from the light, verbenas grew tall and slender, even



FIG. 13.—*Effect of Electric Light upon Petunias.*

taller than in the dark house, and the difference in the time of flowering was very little.

A few fuchsias were grown in both houses. Those in the light house were about eight feet from the lamp, and they flowered three days earlier than the others. The colors were not changed.

Heliotropes of various named varieties standing nine and ten feet from the lamp did not appear to be affected in any way.

White ageratums stood at three feet from the lamp. The flowers soon turned brown and sere. Those in the dark house remained white three times as long.

Chinese primulas at seven feet from the light were not affected, but those four feet away, especially the lilacs, were changed in color. The lilac was bleached out to pure white wherever the light struck squarely upon the flowers, but any portion of the flower which chanced to be shaded by a leaf or another petal retained its color for a time, and then gradually became duller. The exact shape of the shadow could be distinguished during the day. It was noticed that the bleaching was most apparent when the lamp had not been running for a few days; but this was simply because the loss of color took place within a few hours rather than slowly from the opening of the bud.

Petunias were much affected by the light. The plants were much taller and slenderer in the light, even at the farthest corners of the house, and they bloomed earlier and more profusely. Feb. 24th, when measurements were taken, it was found that the height of plants in the dark house was to height of those in the light house as 5 is to 6. Fig. 13 shows the difference well. The three front plants (A, B, C) grew 14 feet from the light, and the rear plants (D, E, F) grew in the dark house. White petunias were not changed in color by the light, but purple ones quickly became blue, especially near the lamp. The flowers near the light shrunk in size the first day or two and the texture became thin and flabby. During the moonlight nights of March, when the light was not running, many purple petunias opened near the lamp. The first night following, the lamp burned six hours, and the next morning nearly all the flowers five within feet were blue where the light had struck them squarely, and later they changed to a dirty white. Flowers which opened when the light was running every night were not so soon affected.

Coleus plants of various colors were placed at different distances from the lamp March 31st. After two nights the plants within three feet of the lamp were much affected. Reds became yellow, browns turned to green, greens lost their brightness, and dark purple became glossy black. Whenever shadows of other leaves protected the foliage the color was unchanged, and the precise limits of the shadow, even to the teeth of the overhanging leaves, were visible for days afterwards. Plants five feet away were little affected at this time, and those 12 feet away were unchanged. Five days later, brown foliage seven feet from the lamp had become greenish in color. During April all coleuses 10 and 12 feet from the light were uninjured, but in January and February they gradually became duller in color at that distance, especially the browns, which appear to be particularly susceptible to the influence of the light. This difference between the results of April and January is undoubtedly due to the greater number of hours of electric light in the long nights of midwinter; and by a reference to the record on page 100 it will be seen that for eleven consecutive nights in April the light did not run.

Observations were made upon the duration of flowers of various colors and species in both houses, and they are tabulated below. By duration of the flower, as recorded in the third column of figures, is meant the total number of days which it remained "open" and held its shape. In many cases, especially near the lamp, the flowers became discolored soon after opening, but still remained open many days. The table also gives some interesting data concerning the duration of flowers as influenced by distance from the lamp. In the table, each entry represents an individual flower, which was ticketed and carefully watched.

SERIES A. FROM JANUARY 16TH TO MARCH 31ST, 1891.

PLANT.	Electric Light House.				Normal or Dark House.	
	Color of flower.	Distance from light. Feet.	Hours of light upon the flower	Duration of flower. Days.	Color of flower.	Duration of flower. Days.
Cuphea hyssopifolia	Pink.	5	70.5	14	Pink	10
	"	"	47.	8	"	8
	"	"	46.5	8	"	9
	"	"	17.	7	"	12
	"	"	35.	6	"	7
	"	"	36.5	9	"	8
	"	"	24.	8	"	10
				8 57	"	7
				Average	"	8
					"	7
					"	10
					"	8
					"	9
					"	8
						8 64
						Average
Heliotrope	White.	8	45.	16	White	16
	"	"	50.5	14	"	15
	"	"	55	16	"	22
	"	"	50	15	"	22
				15.25	"	16
				Average	"	17
					"	18
					"	19
						18.12
						Average
	Blue	8	33	14	Blue.	15
	"	"	46.5	12	"	16
	"	"	36.5	13	"	12
	"	"	50	14	"	15
	"	"	39	14	"	14
	"	"	39	14	"	15
	"	"	29	13	"	13
	"	"	24	14	"	13
	"	"	14	14		
	"	"	14	14		
				13.6		14.12
				Average		
Ageratum.....	White	3	2.15	10	White	25

SERIES A. FROM JANUARY 16TH TO MARCH 31ST, 1891.—*Continued.*

PLANT.	Electric Light House.				Normal or Dark House.	
	Color of flower.	Distance from light. Feet.	Hours of light upon the flower	Duration of flower. Days.	Color of flower.	Duration of flower. Days.
Petunia.....	White	5	30	7	White.	14
	"	7	34	13	"	11
	"	7	24	9	"	15
	"	7	19	10	"	11
	"	7	19	10		10
	"	8	50	10		
	"	10	14	11		12.2
	"	11	20	4		Average
	"	11	39	10		
				9.33	Purple	16
				Average	"	13
					"	11
					"	16
	Purple.	5½	70.5	13	"	9
	"	5½	50.5	11	"	15
	"	6	27.5	12	"	11
	"	6	30	7	"	12
	"	7	39	12	"	12
	"	7	25	10	"	15
	"	7	27.5	12	"	14
	"	8	36	8	"	12
	"	8	19	8	"	12
	"	8	33	11	"	12
	"	8	14.5	7	"	15
	"	9	39	8	"	14
	"	10	24	6	"	10
	"	12	29	11	"	11
	"	14	14	10	"	13
	"	15	55	11	"	11
				9.81	"	15
				Average	"	16
					"	15
					"	14
					"	8
					"	10
					"	13
						12.77
						Average

SERIES A. FROM JANUARY 16TH TO MARCH 31ST, 1891.—*Continued.*

PLANT.	Electric Light House.				Normal or Dark House.	
	Color of flower.	Distance from light. Feet.	Hours of light upon the flower.	Duration of flower. Days.	Color of flowers.	Duration of flower. Days.
Primula	White	5	58	10	White	23
	"	"	56.5	12	"	21
	"	"	44.5	8	"	19
	"	"	53	14	"	21
	"	"	52	17	"	21
	"	"	36	8	"	17
	"	"	42	12	"	18
	"	"	27	9	"	14
	"	"	30.5	12	"	17
	"	"	32	12	"	13
	"	"	55	10	"	17
				11.27	"	25
				Average	"	19
					"	16
	Lilac.				"	17
	"				"	15
	"				"	19
	"				"	13
	"				"	15
	"				"	15
	"					17.75
	"					Average
	"	5	39	11		
	"	"	28	11	Lilac.	15
	"	"	24	10	"	17
	"	"	64	20	"	11
	"	"	44	10	"	14
	"	"	11	15	"	17
	"	"	55	11	"	16
	"	"	14	13	"	18
	"	"	56	16	"	13
	"	"	39	17	"	18
	"	"	50	16	"	18
	"	"	39	17	"	14
	"	"	35	7	"	12
				13.38		
				Average		15.25
						Average

SERIES A. FROM JANUARY 16TH to MARCH 31ST, 1891.—*Continued.*

PLANT.	Electric Light House.				Normal or Dark House.	
	Color of flower.	Distance from light. Feet.	Hours of light upon the flower.	Duration of flower. Days.	Color of flowers.	Duration of flower. Days.
Verbena	Blue.	3	40	10	Blue	11
	"	5	61	11	"	9
	"	3	7	3	"	11
	"	"	3.5	2	"	6
	"	"	39	14	"	6
	"			8	"	10
	"			Average	"	10
	"				"	7
	"				"	10
						8.88
						Average
	Red.	1½	17	8	Red	7
	"	1½	17	6	"	8
	"	2	36	6	"	2
	"	3	12.5	4	"	11
	"	4	46	8	"	8
	"	3	23	4	"	5
	"	"	15.5	5	"	7
	"	"	7	4		
	"	"	24	7		6.86
	"	"	51	9		Average
				6.1		
				Average		

SERIES B. FROM APRIL 1ST TO MAY 1ST, 1891.

PLANT.	Electric Light House.				Normal or Dark House.	
	Color of flower.	Distance from light. Feet.	Hours of light upon the flower.	Duration of flower. Days.	Color of flower.	Duration of flower.
Chrysanthemum	White.	12	45	19	White	18
	"	12	33.5	21		
				20 Average		
Fuchsia.....	—	8	25.5	8	—	9
	—	8	17.5	8		
				8 Average		
Heliotrope.....	White	7	41.5	13	White	16
					"	19
					"	11
						15.3 Average
	Blue	4	49.5	14	Blue	14
	"	5	13.5	11	"	12
	"	8	49.5	13	"	11
	"	9	29.5	14	"	10
	"	10	14	11		
				12.6 Average		11.75 Average
Petunia	White	4	7		White	14
	"	5	33.5	9		
	"	5	14	12		
	"	6	16.5	9		
	"	7	46	8		
	"	9	37.5	11		
	"	10	42.5	10		
	"	12	13.5	10		
	"	13	14	7		
				9		11.2 Average
				9.44 Average		
	Purple	1½	Did not open		Purple	13
	"	3	59.5	13		
	"	3	25.5	7		
	"	4	16.5	8		
	"	4	34	9		
	"	7	14	9		
	"	7	22.5	10		
	"	10	37.5	10		
	"	12	59.5	15		
	"	13	25.5	8		
				9.88 Average		10.25 Average

SERIES B. FROM APRIL 1ST TO MAY 1ST, 1891.—*Continued.*

PLANT.	Electric Light House.				Normal or Dark House.	
	Color of flower.	Distance from light. Feet.	Hours of light upon the flower.	Duration of flower. Days.	Color of flower.	Duration of flower.
Primula	White	3	49.5	14	White	14
	"	3	16.5	12	"	13
	"	4	23	18	"	13
	"	7	25.5	15	"	16
	"	7	25.5	19		
	"	8	7	13		14
	"	9	19.5	14		Average
	"	10	37.5	12		
				14.62		
				Average		
	Lilac	4	49.5	14	Lilac	13
	"				"	17
				"	15	
					15	
					Average	
Verbena	Blue				Blue	15
	"	4	10.5	8	"	12
	"	4	22.5	10		
	"	5	31.5	10		
	"	5	10.5	9		13.5
	"	6	39.5	10		Average
	"	6	7	9		
	"	7	7	10		
	"	7	0	7		
	"	10	23.5	13		
	"	11	7	11		
				9.7		
				Average		
	Red	2	7	7	Red	10
	"	2	10.5	11	"	9
	"	3	26	7	"	10
	"	4	25.5	14	"	5
	"	4	22.5	10	"	9
"	6	19.5	9	"	11	
			9.66			
			Average		9.14	
					Average	

Perhaps the most noticeable feature of these figures is the lack of uniformity in duration under similar conditions. Neither the distance from the lamp nor the hours of light received by the flower appears to determine the duration. The longevity of the flower is probably determined more by the vigor and general condition of the plant than by the variations in the amount of light, although this subject is one which demands closer investigation. In all the observations recorded above, care was exercised to secure plants of like age and vigor. But if the figures of individual flowers give varying results, the averages in the first series (Jan. 16 to Mar. 31), when there were more hours of electric light, are uniformly larger in the dark house specimens. In the second series (April) the averages are not uniform. One is tempted to construct various comparisons from the tables, but the observations are so few that perhaps no other conclusion should be drawn at present but this,—that the duration of flowers is not so much influenced by the electric light at exhibition halls as is generally supposed.

Numerous auxanometer* readings were made upon representative plants in both houses during 1890 and 1891. The following record of the growth of two petunia plants, alike in all respects, will be sufficient for the present purpose :

DATE. 1891.	In electric light house. Plant 12 feet from the lamp.			In normal house.		
	8 p. m.—11 p. m. Electric light run- ning.	11 p. m.—8 a. m. Dark, until day- light.	8 a. m.—8. p. m. Day- light.	8 p. m.—11 p. m. Dark.	11 p. m.—8 a. m. Dark, until day- light.	8 a. m.—8 p. m. Day- light.
Apr. 27 ...	.25 in.	.0625 in.	.5 in.	.15625 in.	.0625 in.	.625 in.
" 29 ...	.00	.3125 "	.125 in.	.00	.125 "	.25 "
" 30 ...	.125 "	.125 "	.5 "	.00	.375 "	.0625 in.
May 1 ...	.125 "	.375 "	.375 "	.125	.25 "	.1875 "
	.50	.875 in.	1.5 "	.28125 in.	.8125 in.	1.1250 in.
	Total growth 2.875 ins.			Total growth 2.21875 in.		

*An auxanometer is an instrument for measuring the growth of plants. The record is usually made continuously upon a revolving cylinder connected with a clock, so that the amount of growth can be determined for any hour of the day.

The average growth per hour is as follows :

8 P. M.—11 P. M.	11 P. M.—8 A. M.	8 A. M.—8 P. M.	8 P. M.—11 P. M.	11 P. M.—8 A. M.	8 A. M.—8 P. M.
Electric light.					
.0416 in.	.0243 in.	.0312 in.	.0234 in.	.0225 in.	.0234 in.

The greatest growth took place when the electric light was burning.

In all these experiments with ornamental plants, it was noticeable that the light exercised a very injurious effect within a radius of about six feet. Between six and eight feet the results were indifferent, and beyond that point there was usually a noticeable tendency towards a taller and straighter growth, and it seemed to us that at distances of a dozen feet or more the flowers were more intense in color, particularly when they first opened. There was usually a perceptible gain in earliness in the light house, also. On the whole, I feel that it will be possible some day to use the electric light in floricultural establishments to some pecuniary advantage. If we have not determined the distance to which the beneficial influence of the light extends, we have nevertheless defined with some degree of accuracy for a few species the limits of its injurious influence.

II. EXPERIMENTS ELSEWHERE.

The first experiment to determine the influence of electric light upon vegetation was made by Hervé-Mangon in 1861.* This experiment showed that the electric light can cause the production of chlorophyll or the green color in plants, and also that the light can produce heliotropism, or the phenomenon of turning or bending towards the light.

In 1869 Prillieux† showed that the electric light, in common with other artificial lights, is capable of promoting assimilation, or the decomposition of carbon dioxide and water.

The next experiments appear to have been those of C. W. Siemens, in England, and P. P. Dehérain in France. These two, with our own, appear to be the only definite investigations of the subject upon what may be called a practical or horticultural scale.

*Compt. Rend. 53, 243.

†Compt. Rend. 69, 410.

The English experiments, although eminently practical, were conducted by an electrician, and the French were largely confined to physiological problems. It seemed proper that the third series of experiments should be approached from the particular standpoint of the gardener.

Dr. Siemens' experiments* may be divided into two series: in one series the lamp was placed inside the greenhouse, and in the other suspended over it. In both cases he observed marked effects upon vegetation in a short time. A great variety of plants was treated. The dynamo which Siemens' in his first experiment used "makes 1,000 revolutions a minute, it takes two horse-power to drive it, and develops a current of 25 to 27 webers of an intensity of 70 volts." "The light produced is equal to 1,400 candles measured photometrically." When the lamp was placed inside the house, plants within three or four feet of it suffered much, the leaves of melons and cucumbers "which were directly opposite the light turning up at the edges and presenting a scorched appearance." When these injured plants were removed to a distance of seven or eight feet they showed "signs of recovery, throwing out fresh leaves and pearls of moisture at their edges." In general, all plants which were exposed to normal conditions during the day and to six hours of electric light at night "far surpassed the others in darkness of green and vigorous appearance generally." The flavor was fully as good in the electric light fruits as in the others. These results were supplemented by a larger experiment in the winter of 1880-81. In this case a lamp of 4,000 candle power was used, and it was placed inside a house of 2,318 cubic feet capacity. The light was run all night, and the arc was at first not protected by a globe. The "results were anything but satisfactory," the plants soon becoming withered. At this point a globe of clear glass was placed upon the lamp, and thereafter the most satisfactory results were obtained. Peas, raspberries, strawberries, grapes, melons and bananas fruited early and abundantly under continuous light,—solar light by day and electric light by night. The strawberries are said to have been "of excellent flavor and color," and the grapes of "stronger flavor than usual." The

*Proc. Royal Soc. xxx. 210 and 293. Rep. British A. A. S. 1881, 474. See also abstract in *Nature* xxi. 456 (Mch. 11, 1880), and an editorial in the same issue.

bananas were "pronounced by competent judges unsurpassed in flavor" and the melons were "remarkable for size and aromatic flavor." Wheat, barley and oats grew so rapidly that they fell to the ground of their own weight. The beneficial influence of the clear glass globe was therefore most marked. "The effect of interposing a mere sheet of thin glass between the plants and the source of electric light was most striking. On placing such a sheet of clear glass so as to intercept the rays of the electric light from a portion only of a plant—for instance, a tomato plant—it was most distinctly shown upon the leaves. The portion of the plant under the direct influence of the naked electric light, though at a distance from it of nine or ten feet*, was shrivelled, whereas that portion under cover of the clear glass, continued to show a healthy appearance, and this line of demarkation was distinctly visible on individual leaves; not only the leaves but the young stems of the plants soon showed signs of destruction when exposed to the naked electric light, and these destructive influences were perceptible, though in a less marked degree, at a distance of twenty feet from the source of light."

In the other series of experiments, Siemens placed an electric lamp of 1400 candle power about seven feet above a sunken melon pit which was covered with glass. The light was modified by a clear glass globe. In the pit seeds and plants of mustard, carrots, turnips, beans, cucumbers and melons were placed. The light ran six hours each night and the plants had sunlight during the day. In all cases those plants "exposed to both sources of light showed a decided superiority in vigor over all the others, and the green of the leaf was of a dark rich hue." Heliotropism was observed in the young mustard plants. Electric light appeared to be about half as effective as daylight. A great difficulty experienced in this experiment was the film of moisture which condenses on greenhouse roofs at night and obstructs the passage of light. The light was at one time suspended over two parallel pits nearly four feet apart, and the effect was observed upon plants under the glass and in the uncovered space. In all cases the growth of the plants was hastened. Flowering was hastened in melons

*It is to be observed that the light used by Dr. Siemens in this case was 4,000 candle power, while ours was but 2,000.

and other plants under the glass. Strawberries which were just setting fruit, were put in one of the pits and part of them were kept dark at night while the others were exposed to the light. After fourteen days, the light having burned twelve nights, most of the fruits on the lighted plants " had attained to ripeness, and presented a rich coloring, while the fruit on those plants that had been exposed to daylight only had by this time scarcely begun to show even a sign of redness." He concludes that a lamp of 1400 candle power produced a maximum beneficial result on vegetation at a distance three metres (nearly ten feet) above the glass, but "the effect is nevertheless very marked upon plants at a greater distance."

At the close of his experiments Siemens was very sanguine that the electric light can be profitably employed in horticulture, and he used the term "electro horticulture" to designate this new application of electric energy. He anticipated that in the future "the horticulturist will have the means of making himself practically independent of solar light for producing a high quality of fruit at all seasons of the year." He had shown that growth can be hastened by the addition of electric light to daylight, that injury does not necessarily follow continuous light throughout the twenty-four hours, that electric light often deepens the green of leaves and the tints of flowers and sometimes intensifies flavors, and that it aids to produce good seeds; and he thought that the addition of the electric light enabled plants to bear a higher temperature in the greenhouses than they otherwise could. But whatever may be the value of the electric light to horticulture, the practical value of Siemens' experiments is still great. They have furnished data in several obscure relations of light to vegetation. *Nature* made the following comments upon this feature of the application of the electric light by Dr. Siemens: "But the scientific interest of its present application must rest mainly on the fact that the cycle of the transformation of energy engaged in plant life is now complete, and that, starting from the energy stored up in vegetable fuel, we can run through the changes from heat to electricity, and thence to light, which we now know we can store up in vegetable fuel again."

Dehérain's experiments* were conducted at the Exposition d'Électricité, Paris, in 1889. A small conservatory standing inside the Exposition building was divided into two compartments. One compartment was darkened and the glass painted white upon the inside ; this received the electric light and all solar light was excluded. The other compartment was not changed. The amount of sunlight which the plants normally received in this conservatory within an exposition was not sufficient to maintain a healthy growth. A lamp of 2,000 nominal candle power was used. At first the naked electric light was used and it ran continuously. Barley in head and flax in flower were brought into the lighted compartment ; also chrysanthemums, pelargoniums, roses, and a variety of ornamental plants. After seven days of continuous electric lighting most of the plants were seriously injured. All the pelargoniums lost their leaves, cannas were discolored, four o'clocks were tarnished, and bamboos were blackened. "But the most curious effect was produced upon the lilacs ; all the parts of the leaves that had received the direct rays from the lamp were blackened, while those protected by the upper leaves preserved their beautiful green color, and the impression produced upon the epidermis by the electric rays had the clearness of a photographic plate." Similar effects were produced upon azaleas, deutzias and chrysanthemums. It was found that this discoloration did not extend beyond the first layer of palisade cells. Plants which received solar light by day and electric light at night only were injured in the same manner but in a less degree. The injury was most marked upon the old leaves. The pelargoniums soon sent out new shoots and the young leaves resisted the action of the light much longer than did the mature ones. The flax continued to grow and the barley ripened. It was found that plants under the electric light alone were able to assimilate, but the action was very slow. As much assimilation took place in an hour on a bright summer day as in several days of electric light. At the expiration of two weeks the condition of the plants was so bad that a change was made, and thereafter a globe was used upon the lamp.

The experiment with modified light, by the use of a transparent glass globe, was conducted like the preceding. Sprouting seeds in electric light alone grew for a short time, then drooped and died,

*Ann. Agronom. vii. 551 (1881).

not being able to make true leaves. Sprouting maize turned black, but maize in full growth remained in apparently good condition though not growing, even for two months. New leaves appeared on roses and other plants, but growth was slow or none. Flowers did not appear, and seeds did not mature in previously formed fruits, except in the case of barley, which made good seeds. New growths appeared at the base of some plants and the petioles of pelargoniums became very much elongated. Many plants remained almost stationary throughout. Assimilation was more feeble than under the naked light. Plants which had been set out of doors during the day and brought into the electric light house at night, did not behave any better, if as well, than those left out of doors continuously. Dehérain's account is replete with interesting speculations upon the physiology of the plants under experiment. His general conclusions of the influence of electric light upon plants, are as follows:

"1. The electric light from lamps contains rays harmful to vegetation.

"2. The greater part of the injurious rays are modified by a transparent glass.

"3. The electric light contains enough rays to maintain full grown plants two and one-half months.

"4. The light is too weak to enable sprouting seeds to prosper or to bring adult plants to maturity."

Finally, observations* were made more recently upon the influence of the electric light upon plants in the winter palace at St. Petersburg. It was observed that in a single night ornamental plants turned yellow and then lost their leaves. Yet it is well known that incandescent lamps can be lodged in the corolla of a flower without injuring it.

RECAPITULATION.

It is impossible to draw many definite conclusions from the above researches. The many conflicting and indefinite results indicate that the problems vary widely under different conditions and with different plants. Yet there are a few points which are clear: the electric light promotes assimilation, it often hastens growth and maturity, it is capable of producing natural flavors

*Ann. Agronom. xiv. 281 (1888).

and colors in fruits, it often intensifies colors of flowers and sometimes increases the production of flowers. The experiments show that periods of darkness are not necessary to the growth and developments of plants. There is every reason, therefore, to suppose that the electric light can be profitably used in the growing of plants. It is only necessary to overcome the difficulties, the chief of which are the injurious influences upon plants near the light, the too rapid hastening of maturity in some species, and in short, the whole series of practical adjustments of conditions to individual circumstances. Thus far, to be sure, we have learned more of the injurious effects than of the beneficial ones, but this only means that we are acquiring definite facts concerning the whole influence of electric light upon vegetation; and in some cases, notably in our lettuce tests, the light has already been found to be a useful adjunct to forcing establishments.

The experiments suggest many physiological speculations upon which it is not the province of this bulletin to enter. Yet two or three of them may be mentioned. It is a common notion that plants need rest at night, but this is not true, in the sense in which animals need rest. Plants have simply adapted themselves to the conditions of alternating daylight and darkness, and during the day they assimilate or make their food and during the night, when, perforce, assimilation must cease, they use the food in growth. They simply practice an individual division of labor. There is no inherent reason why plants cannot grow in full light, and, in fact, it is well known that they do grow then, although the greater part of growth is usually performed at night. If light is continuous, they simply grow more or less continuously, as conditions require, as they do in the long days of the arctic regions, or as our plants did under continuous light. There is no such thing as a plant becoming worn out or tired out because of the stimulating influence of continuous light.

It would seem, therefore, that if the electric light enables plants to assimilate during the night and does not interfere with growth, it must produce plants of great size and marked precocity. But there are other conditions, not yet understood, which must be studied. Our radish plants, and many others, were earlier but smaller under the influence of the light. Observation and chemical examination showed that a greater degree of maturity had

been attained. Perhaps they assimilated too rapidly, perhaps the functions of the plant had been completed before it had had time to make its accustomed growth. Perhaps the highly refrangible and invisible rays from the electric lamp have something to do with it. In fact, this latter presumption probably accounts for much if not all of the injury resulting from the use of the naked light, for the effect of the interposition of a clear pane of glass is probably to absorb or obstruct these rays of high refrangibility. Good results which follow the use of a globe or a pane of glass show, on the other hand, that the injury to plants cannot result from any gases arising from the lamp itself, as has been supposed by some observers. In our own experiments, particularly with the Brush lamp, there was no perceptible odor from the gases of combustion ; and it may also be said that commercial forcing-houses, like our own, are not tight enough to hold sufficient quantities of these gases to injure plants.

It is highly probable that there are certain times in the life of the plant when the electric light will prove to be particularly helpful. Many experiments show that injury follows its use at that critical time when the plantlet is losing its support from the seed and is beginning to shift for itself, and other experiments show that good results follow its later use. This latter point appears to be contradicted by Dehérain's results, but his experiments were not conducted under the best normal conditions.

On the whole, I am inclined towards Siemens' view that there is a future for electro-horticulture.

L. H. BAILEY.

CORNELL UNIVERSITY

Agricultural Experiment Station.

BULLETIN 31.

HORTICULTURAL DIVISION.

SEPTEMBER, 1891.

THE FORCING OF ENGLISH CUCUMBERS.

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BULLETINS OF 1891.

26. Experiences with Egg Plants.
27. The Production and Care of Farm Manures.
28. Experiments in the Forcing of Tomatoes.
29. I. Cream Raising by Dilution.
II. The Effects of a Delay in Setting on the Efficiency of Creaming.
III. Application of Dr. Babcock's Centrifugal Method to the Analysis of Milk, Skim Milk, Butter-milk and Butter.
IV. The Relation of Fibrin to the Effectual Creaming of Milk.
30. Some Preliminary Studies of the Influence of the Electric Arc Lamp upon Greenhouse Plants.
31. The Forcing of English Cucumbers.

NOTES OF TOMATOES.

I. 1891.

1. *Studies of Fertilizers*.—During three years, both in the field and forcing-house, we have made observations which show that the common notion that heavy fertilizing of tomatoes tends to lessen yields is open to criticism. Our tests uniformly give larger yields in heavily fertilized land. Yet there is undoubtedly some reason for the widespread belief to the contrary. Much may depend upon soil, and still more upon the character of fertilizer used. Heavy fertilizing, when beneficial, starts off the plant rapidly early in the season and hastens the appearance of fruit; and productiveness in the tomato is largely a question of earliness, or the ability of the plant to give the maximum number of pickings before frost. It is conceivable that raw and coarse stable manures, in which the plant foods are not quickly available, may show the greater part of their effects late in the season when vigorous growth is not needed. Whatever the fertilizer applied, it should present the plant foods in the most available form in order that the plants may reap the benefits at once. In our experiments we used the best and most thoroughly disintegrated manure which could be obtained from our stables.

In order to determine if the late application of fertilizer tends to decrease productiveness before frost, we this season set aside 34 plots for treatment. In order to bring them entirely under control and to insure uniform conditions, only three plants were grown upon a plot, while the large number of plots may be supposed to eliminate whatever error may arise from the use of so small an area. The plots were divided into two lots of 17 each, and each lot received 10 lbs. of nitrate of soda. In Lot I the material was all applied at once, June 25, 15 days after the plants were set in field. In Lot II the nitrate was applied at intervals, as follows: 2 lbs. June 25; 2 lbs. July 13; 3 lbs. August

3; 3 lbs. August 28. The plots were all contiguous and occupied a total area of 1600 square feet, or about one twenty-seventh of an acre. Each lot or half, therefore, contained about one-fifty-fourth of an acre, and received nitrate of soda at the rate of 540 pounds to the acre. The nitrate was sown broadcast, and all except the last application in Lot II — which was allowed to lie on the surface—were lightly hoed in. The soil is a good light gravelly loam which has been in garden use for some years, and which would raise a fair crop of potatoes or corn without manure. The plants were all *Ignotum*, and were set in the plots June 10. The results of this experiment are presented in two tables, the former showing the yields previous to the last picking, and the latter including the last picking (October 5) or the total crop of the season :

TABLE I.—ONE vs. SEVERAL FERTILIZINGS.

Crop previous to the last picking.

PLOTS.	Lot I. One application (10 lbs.).			Lot II. Four applications (10 lbs.).		
	Average no. fruits per plant.	Average weight of crop per plant. Lbs.	Average wt. of individ- ual fruits. Ozs.	Average no. fruits per plant.	Average weight of crop per plant. Lbs.	Average wt. of individ- ual fruits. Ozs.
No. 1.	14.	15.3	6.1	9.3	4.2	7.3
No. 2.	8.3	4.2	8.	9.	3.9	6.8
No. 3.	11.	3.9	5.6	14.3	5.2	5.8
No. 4.	13.3	5.2	6.3	8.6	3.1	5.7
No. 5.	16.3	5.2	5.2	17.6	5.3	5.
No. 6.	9.7	3.4	6.	9.	2.8	5.
No. 7.	8.	2.3	4.7	8.	2.6	5.3
No. 8.	15.3	5.4	5.7	15.	4.2	4.5
No. 9.	16.6	5.4	5.3	13.	5.	6.
No. 10.	21.	5.8	4.4	21.3	6.6	4.9
No. 11.	11.6	4.4	6.2	12.	4.	5.2
No. 12.	18.	6.3	5.6	11.3	4.5	6.2
No. 13.	13.3	4.8	5.7	15.3	5.7	5.7
No. 14.	17.6	7.4	6.7	15.	5.	5.3
No. 15.	17.6	6.1	5.5	12.3	5.	6.5
No. 16.	16.	4.4	4.2	20.3	6.9	5.4
No. 17.	14.6	4.8	5.4	13.6	4.7	5.4
Totals..	14.2	5.5	5.7	13.2	4.6	5.6

TABLE II.—ONE vs. SEVERAL FERTILIZINGS.

The season's crop.

PLOTS.	Lot I. One application (10 lbs.).			Lot II. Four applications (10 lbs.).		
	Average no. fruits per plant.	Average weight crop per plant. Lbs.	Average wt. of individ- ual fruits. Ozs.	Average no. fruits per plant.	Average wt. crop per plant. Lbs.	Average wt. individual fruits. Ozs.
No. 1.	25.3	9.1	5.8	26.3	9.9	6.
No. 2.	14.3	6.2	6.9	23.6	9.2	6.2
No. 3.	19.3	6.3	5.3	25.3	9.4	5.9
No. 4.	16.3	6.5	6.4	14.6	5.1	5.7
No. 5.	22.3	7.4	5.3	28.3	9.	5.1
No. 6.	15.6	6.	6.1	23.	7.3	5.1
No. 7.	19.6	6.5	5.3	23.3	6.6	4.6
No. 8.	23.3	8.	5.5	21.3	5.9	4.5
No. 9.	27.6	8.8	5.1	25.	8.9	5.7
No. 10.	28.3	7.5	4.2	30.5	9.4	5.
No. 11.	22.	7.1	5.1	22.	7.6	5.6
No. 12.	28.6	9.2	5.1	19.6	7.2	5.8
No. 13.	25.6	8.6	5.3	24.3	8.2	5.4
No. 14.	27.	9.9	5.9	25.6	8.9	5.5
No. 15.	27.3	8.3	4.9	30.6	7.6	5.8
No. 16.	28.	6.8	3.9	31.	10.	5.2
No. 17.	21.3	6.6	4.9	22.3	7.8	5.6
Totals...	23.	7.5	5.4	24.5	8.1	5.4

These figures show striking results of the effect of late applications of fertilizer. In Table I, which shows the yields up to the last week in September, Lot I, or those plants receiving the fertilizer in one application, gives much better results than Lot II, there being a gain of nearly 8 per cent. in number of fruits per plant and nearly 20 per cent. in total average weight of crop. In Table II, however, which shows the crops after the last picking was added, Lot II gives the best results, showing a gain of more than 6 per cent. over Lot I in number of fruits per plant, and 8 per cent. in average weight of crop. This means that the intermittent application of fertilizer in Lot II was beginning to be felt late in the season, while the single early application of the same amount of fertilizer gave quicker results. Frost held off until the second week of October, so that it happened that the intermittent fertilizing gave us the better result, but had frost come the last of

September, as it frequently does at Ithaca, it would have given us the poorer result. It is therefore not advisable to apply nitrate of soda to tomatoes in this climate so late as the latter part of August. On the other hand, the tables show that the nitrate gives better results when applied two or three times than when the same amount is applied at once, for the total yield in Table II surpasses that in Table I. Nitrate of soda is one of the few fertilizers which readily escapes in the drainage, and probably more of it is lost when one heavy application is made than when the same amount is distributed through the season in several light applications.

The general conclusion of this test is that nitrate of soda, if used in large amounts, should be applied at intervals in order to obtain best yields, but care must be exercised not to apply it so late that its effects cannot be felt before frost; and liberal early application is advisable. These results recall those obtained by Voorhees at the New Jersey Experiment Station.* He found that two applications of nitrate of soda increased yield without delaying maturity, while one heavy early application increased yield at the expense of maturity. The New Jersey tests were designed to show the effects of nitrate upon the early crop, that maturing during July and August, while ours concerned itself with the amount of crop obtained during the entire season. The experiments are therefore not strictly comparable, and the dissimilar results may be due to some facts not considered in either one, as difference in soil or treatment.

So much has been said of late concerning the value of nitrate of soda as a fertilizer that there is a tendency to apply it to the exclusion of other materials. It should be borne in mind that this substance is an incomplete fertilizer and that unless the soil contains potash and phosphorus in sufficient amount the nitrate is nearly valueless. It is simply a convenient and useful form in which to apply nitrogen alone. Our experiments of last year† showed that nitrate of soda gave no increased yield upon poor soil, and Voorhees' tests, quoted above, show that the effect of nitrate was "dependent upon the presence or absence in the soil of

*Bulletin 79, N. J. Exp. Sta. Feb. 1891.

†Bull. xxi. Cornell Exp. Sta. 77.

a full supply of the mineral elements, phosphoric acid and potash." In order to determine the value of nitrate of soda when used alone and in combination with potash and phosphorus, and incidentally to afford other data upon the feeding capacity of the tomato, 7 plots of one-fortieth acre each were set aside for treatment. The soil is a hard, stony clay loam of poor quality. It has been cropped for many years and has never received fertilizers of any kind. The experiment follows the method advised by the Office of Experiment Stations of the United States Department of Agriculture.* The plants were all *Ignotum*, which were set in the field June 12. The fertilizers were sown broadcast June 20 and were allowed to lie upon the surface until covered by the regular cultivation. The treatments and results are as follows :

TABLE III.—FERTILIZER TEST.

Plot.	Average no. of fruits per plant.	Average. wt. fruit per plant. lbs.	Average wt. of individual fruits. Ozs.
1. Nitrate of Soda. 4 lbs.	4.9	1.7	5.5
2. Bone black. 8 lbs.	4.7	2.1	7.3
3. Muriate of Potash. 4 lbs.	6.5	2.9	7.0
4 { Nitrate of Soda. 4 lbs.	6.2	2.2	5.6
{ Bone black. 8 lbs.			
5 { Nitrate of Soda. 4 lbs.	5.2	1.8	5.5
{ Muriate of Potash. 4 lbs.			
6 { Bone black. 8 lbs.	4.8	1.9	6.3
{ Muriate of Potash. 4 lbs.			
7 { Nitrate of Soda. 4 lbs...	6.2	3.3	8.7
{ Bone black. 8 lbs.			
{ Muriate of Potash. 4 lbs.			

These figures show that, in single treatments, nitrate of soda gave poorest results, bone black intermediate results, and muriate of potash the best results. If one were to make a combination of any two of these, he should expect, therefore, to secure the highest results from muriate of potash and bone black, but the best yield in double combination came from nitrate of soda and bone black. A combination of the three materials gave the best results, but even this was not sufficient to produce a heavy yield. These figures, like all results of fertilizer experiments

*Circular No. 7, Comparative Field Experiments with Fertilizers, 17.

made in even the most painstaking manner, must not be interpreted rigidly; in another season, they would be likely to give different figures, but the table seems to show clearly the folly of using nitrate of soda alone upon poor soil. Upon good soil, the nitrate gives good results, as is shown by our tests of 1889, and more particularly by the work of Voorhees in New Jersey, already referred to, and Alvord in Maryland.*

The results of fertilizer tests are often so various as to lead to the suspicion that there is a difference between varieties as to the readiness with which they respond to treatment, and it is worth while to enquire if this is in any way associated with amelioration: that is, do the highly improved varieties respond more readily than the small and unimproved ones? This point was tested by selecting for treatment two dozen plants of Ignotum, Ithaca and Golden Fig. The Ignotum and Ithaca, especially the former, may be taken to represent the highly improved sorts, while the plum tomato, Golden Fig, may represent the unimproved ones. Half of the plants received on June 25, 15 days after they were set in the field, a dressing of 2 lbs. nitrate of soda, 2 lbs. muriate of potash, 2 lbs. bone black, and 2 lbs. Bradley's vegetable fertilizer. The other half received no fertilizer. The plants stood along side those discussed in Table III, on poor hard clay loam. The results are as follows:

TABLE IV.—RELATION OF VARIETY TO INFLUENCE OF FERTILIZER.

VARIETY.	Average no. fruits per plant.			Average weight of crop per plant.			Average weight of individual fruit.		
	Unfertilized.	Fertilized.	Per ct. increase.	Unfertilized.	Fertilized.	Per ct. increase.	Unfertilized.	Fertilized.	Per ct. decrease.
Ignotum ...	3.4	11.6	241	1.6	3.5	119	7.3	4.7	36
Ithaca	3.8	21.5	466	2.2	5.9	168	9.3	4.4	53
Golden Fig	31.6	69.6	120	1.5	3.3	120	.74	.74	0

The figures show a decidedly greater tendency on the part of the improved varieties to produce more fruits to the plant, but be-

* 2nd Rep. Md. Exp. Sta. 43. Bull. 11, 58.

cause of the great increase in number, the weight of the fruits falls off. In the unimproved variety the weight of individual fruits remain the same, so that, although it shows a less increase in the number of fruits than the others, it still gives as great increase in total weight of crop as the Ignotum, and gives nearly as many actual pounds of fruit. The Ithaca responds in a remarkable manner to the fertilizer, even though in the unfertilized plot it yields more heavily than the others; but the weight of the fruits shows a nearly corresponding decrease.

2. *Early and Late Setting.*—Last year experiments were made to determine if very early setting of tomatoes in the field is advisable. Plants set early in May and which were subjected to much cold and inclement weather, gave earlier results than those set along with the general planting early in June, and yielded nearly five times as much. The experiment was repeated this year, but the differences were not so marked as last year. The early setting was placed in the field on the same date as last year, May 9. For nearly a month thereafter the weather was very dry, so that the plants had to be watered to keep them alive, and there was some cold, raw and almost frosty weather. The regular setting was made June 10. Two lots of plants were divided into equal portions for separate treatment, and the outcome is as follows:

TABLE V.—EARLY AND LATE SETTING.

Samples.	Date of first picking.	Average no. of fruits per plant.	Average wt. of fruit per plant. Lbs.	Average wt. of individual fruits. Ozs.
Lot I { Early.....	July 9	30.6	6.8	3.5
{ Late.....	July 6	18	6.5	3.8
Lot II { Early.....	July 28	34	10.5	4.9
{ Late.....	July 6	32	7.9	4

The figures show that the early setting, despite the hard weather which it endured, gave larger yields in each case than the late setting, although the first picking was later. The plants were so much retarded by the dry and cold weather that they did not recuperate at once, although their thorough establishment in the soil gave them the advantage so far as total yield before frost is concerned. It appears to be safe to say, therefore, as the result of

two years' tests, that tomato plants are not injured by the cold raw weather of late spring to so great an extent as is commonly supposed, and that very early setting on well prepared ground appears to be advisable. Undoubtedly much depends upon the character of the plants. In the two lots above reported, the plants were transplanted two or three times and were vigorous when set in the field. Another lot was set alongside them which had received but one transplanting, on March 2. These plants gave earlier results when set May 9 than when set June 10. Those which remained in the pots until June were so badly pot-bound that they did not soon recover.

3. *Few and Many Transplantings.*—It is well known that in this latitude at least one or two transplantings of tomatoes are necessary for best results, but the exact relation of number of transplantings to earliness and productiveness has not been determined. Should the plants be transplanted on from pot to pot or box to box as fast as the roots fill the earth, or should one or two or three shiftings suffice? Two series of experiments were made upon this point. In the first series, the plants were set in the field early in May, and in the other they were set in June. This is a part of the test shown in table V. All the plants were sown February 12, and they were all transplanted into 3-inch pots March 2. Some received no further transplanting, and others were shifted once more and others twice more,—into 4-inch pots March 23 and into 5-inch pots May 6. The numerical results are as follows :

TABLE VI.—FEW AND MANY TRANSPLANTINGS.

Samples.	Date of first picking.	Average no. of fruits per plant.	Average wt. of fruit per plant. Lbs.	Average wt. of individual fruits. Ozs.
<i>Series I. Set May 9.</i>				
1. Transplanted once.....	Aug. 17	27.3	8.2	4.7
2. " twice.....	July 28	34	10.5	4.9
3. " three times	July 9	30.6	6.8	3.5
<i>Series II. Set June 10.</i>				
1. Transplanted once.....	Aug. 24	9.7	5.8	4.7
2. " twice.....	July 6	32	7.9	4
3. " three times	July 6	18	6.5	3.8

The results are so marked and so uniform that it seems safe to consider them to be due to the influence of transplanting. The figures show that two transplantings gave larger yields than either one or three, although three transplantings gave earliest fruits in one instance.

4. *Seeds vs. Cuttings.*—Last year some tests were made to determine the relative merits of seedlings and cuttings, and it was found that seeds gave plants twice more productive than cuttings. The relative value of seedlings and cuttings is an important matter, for many growers prefer the latter and carry over a few plants in a greenhouse to afford spring cuttings. The experiment was repeated this year. The cuttings were made from bearing greenhouse plants at the same time that seeds were sown for the competitive plants. All the plants were thereafter handled in exactly the same manner, being transplanted twice and set in the field June 10.

TABLE VII.—SEEDLINGS VS. CUTTINGS.

Samples.	Average no. fruits per plant.	Average wt. of fruit per plant. Lbs	Av'g. wt. of individual fruits. Ozs	Date of first picking.
<i>Lorillard.</i>				
Seedlings	50	13.1	4.2	Aug. 3
Cuttings	14.2	2.9	3.2	July 9
<i>Cuttings of Cuttings.</i>	26	9.8	6	Aug. 17
<i>Ithaca.</i>				
Seedlings	10.3	4	6.2	
Cuttings	26.1	6.2	3.8	

The results from the two lots are unlike. The Lorillard shows a much better crop from seedlings, the weight of crop being over four times greater. In the Ithaca, the results are reversed, but it chanced that the seedling plants, for some unknown reason, were very poor, and therefore not typical for comparison, and the cuttings gave a small yield. Taken in connection with our results last year, the figures seem to justify the statement that as a rule seedling plants give better results than cuttings. The cuttings in both lots gave earlier fruits than the seedlings, amount-

ing to 25 days in the Lorillard, and fully as much in the Ithaca. But some of the cutting plants of Lorillard did not give ripe fruits until July 28, so that there was less actual difference in earliness between seedlings and cuttings than the dates in the last column of Table VII would seem to indicate.

A singular result was obtained by taking cuttings from cutting plants. The original Lorillard cuttings were made February 2 and placed in 3-inch pots. March 12 they were transplanted into 4-inch pots, and a month later cuttings were taken from the side shoots of these plants and struck in 3-inch pots. These were shifted into 4-inch pots May 20, and set in the field June 10, along side the plants from which they were taken. The entry in Table VII gives the numerical results. The first fruits were not obtained until August 17, two weeks later than the seedlings and over five weeks later than the parent cuttings. But the yield was over three times greater than that of the parent plants, and the average weight of individual fruits was nearly twice as great. We are unable to account for this curious result. There was also a great difference in habit between the two. The original cuttings, which were taken from strong growing shoots from near the top of bearing plants, made a tall growth and looked like average seedling plants. The cuttings from them, however, which were taken from much smaller shoots than their parents had been, made very short and stocky plants with a great tendency to branch. Another and more extended experiment upon cuttings will be made the coming season.

5. *Trimming*.—Experiments made last year showed that two light trimmings of field plants considerably increased earliness and productiveness. The plants were headed back from three to six inches on all the leading shoots July 28 and August 25, and the sprouts were removed from the base of the plant. A plot of over 80 plants was set aside this year for further experiments in this direction. Half the plants were allowed to take their natural course, and half were trimmed. The trimming was more severe than last year and it was begun later. August 3 the first treatment was given, all the leading shoots being cut back from six to nine inches. A second similar treatment was made August 24, and a third September 18, when from three to four inches of each

shoot were removed. In all cases the branch was cut just above a flower cluster.

TABLE VIII.—TRIMMED PLANTS.

SAMPLES.	Date of first picking.	Average no. fruits per plant.	Average wt. of crop per plant. Lbs.	Average wt. of individual fruits. Ozs.	Per ct. of gain (+) or loss (—) by number.	Per ct. of gain (+) or loss (—) by weight.
<i>Red Mikado.</i>						
Trimmed.....	Aug. 3...	28.1	12.6	6.7		
Not trimmed.....	Aug. 1...	31	12.2	6.3	—0.9	+ 0.03
<i>Mikado.</i>						
Trimmed.....	Aug. 17..	25.7	14	8.7		
Not trimmed.....	Aug. 17..	36.3	19.7	8.7	—30	—29
<i>Shah.</i>						
Trimmed.....	Aug. 11..	27.5	16	9.3		
Not trimmed.....	Aug. 29..	25.8	18.6	11.5	+0.6	—14
<i>White Apple.</i>						
Trimmed.....	Aug. 24..	70.1	6.7	1.6		
Not trimmed.....	Aug. 17..	58	5.5	1.2	+21	+22
<i>Perfection.</i>						
Trimmed.....	Aug. 11..	43.5	14.8	5.3		
Not trimmed.....	Aug. 11..	39	12.5	5.1	+12	+18
<i>Golden Queen.</i>						
Trimmed.....	Sept. 3..	48	14.3	4.7		
Not trimmed.....	Sept. 3..	50.8	13.6	4.3	—0.5	+0.05
<i>Beauty.</i>						
Trimmed.....	Sept. 3..	36.6	14	6.1		
Not trimmed.....	Sept. 3..	42.3	15.5	5.8	—13	—10

It is evident that the earliness of the different samples counts for nothing, because the trimming was not performed until the fruit was ripe or nearly so; and as earliness in the tomato is correlated with productiveness or length of bearing season, we should expect indifferent results from the whole treatment, and this the table shows. There are only two instances in which there is an unequivocal gain in productiveness—the White Apple and Perfection—and there are two or three cases of decided loss. Last year's results showed decided gains from timely trimming: this year's tests show indifferent or even decreased results from late or

untimely trimming. It is therefore evident that if trimming is to be done at all it must be performed rather early.

6. *Single-Stem Training*.—In our account of forcing tomatoes for winter fruit, it was stated* that the yield was about two pounds per square foot of floor space, which is over three times the yield of a good crop of out-door tomatoes. The question at once arises if the house system of training is practicable for field culture. In the house the plants are trained to a single stem and are held erect by a cord extending from the box in which the plant grows to the roof. Several methods of holding up the plants suggest themselves for field culture. We used, in one experiment, stakes $1\frac{1}{2} \times 1\frac{1}{2}$ in. and five feet high driven securely into the ground. In another we drove the stakes in lightly and held them in place by two wires drawn in between them in an alternating fashion near their tops, the wires being held by posts set every sixteen feet. This made a wire-and-picket fence, except that the lower ends of the pickets were held in the ground. This is the cheapest and best trellis which we tried. Upon firm land it is difficult to drive in the stakes firmly enough to stand with the load of foliage and fruit against storms, and the wire support is a serviceable addition. We also used perpendicular strings stretched between two horizontal wires, one near the ground and the other five feet high, and also one or two other trellises, but they were not so good as stakes supported by wire. The plant was tied loosely to the support at intervals of a foot or so as it grew, and all side shoots were pinched out as fast as they appeared. In this way, only one stem was allowed to grow. The plants were set a foot apart in the row, and the rows were three feet apart. Several varieties were tried, but only the average results are given in the table. Training tomatoes to stakes is by no means a new method, but confining the growth to a single shoot is not often practiced, and there are no accurate figures to show what the merits of the system may be. Two series of trellises were erected, and the same number of plants was set in an ordinary patch along side each one.

*Bull. 28, p 57.

TABLE IX.—SINGLE STEM TRAINING.

Samples.	Crop previous to Aug. 31		Crop for the season.		
	Average no. fruits per plant.	Average wt. fruit per plant. Ozs.	Average no. fruits per plant.	Average wt. fruit per plant. Lbs.	Average wt. of individual fruits. Ozs.
Trellis No. 1.....	.25	1.36	10.1	4.3	6.7
Patch No. 1.....	.10	.64	38.7	11	4.5
Trellis No. 2.....	1.31	5.8	16.2	5.8	5.7
Patch No 2.....	.66	2.5	49	13.9	4.5

The trellis plants bore about a third as many fruits as those lying naturally upon the ground, and nearly half as many pounds of crop. In order to discover the true value of the training, yields must be computed to the square feet of ground occupied. 86 trellis plants set 1x3 ft. occupied 258. sq. ft., while the 85 ordinary plants, at 4x4 ft. occupied 1360 sq. ft. The trellis plants gave 1.6 lb. of ripe fruit to each square foot, while the other plants gave $\frac{3}{4}$ lb., or less than half as much. The single-stem training, therefore, shows an enormous increase in yield over common methods of cultivation ; and it is to be noted, also, that it gave earlier results. We also found, as will be discussed farther on, that rot was much less upon the trellis plants than upon the others.

Although this single-stem training gives greatly increased yield and decreases rot, its value must be determined by its cost. It is impossible to determine from so small an area as the one under experiment, what the expense of the system would be if employed upon a large scale. We kept an accurate account of the labor spent upon the staking and training of these 86 plants and found it to amount to 14 hours for the entire season ; and as a reward we gained about 250 lbs. of product, lost only one-tenth as much from rot, and gained something from earliness. To this expense must be added the cost of posts, stakes and wire, but it must also be considered that if a large plantation were trained the labor would undoubtedly be a half less than upon a small experi-

mental plot. Yet it is doubtful if this single-stem training can be profitably used for the main field crops, but for the early market or choice trade and for home use it appears to possess decided advantages.

7. *Hilling*.—There are gardeners who think that hilling tomato plants, much as potatoes are hilled, is advantageous, and one of our correspondents is enthusiastic over it. A plot of 49 good Ignotum plants was divided into two lots of 28 and 21. The latter were hilled twice, once a couple of weeks after the plants were set and again six weeks later. The soil was hilled up six inches about the plant each time. There was no difference in earliness between the two lots. The hilled plants gave an average of 6.9 fruits to the plant, against 6.1 from the check, 2.8 pounds of fruit against 2.9 pounds, and an average weight of 6.4 oz. of individual fruits against 7.5 in the check lot. The yield in pounds was therefore essentially the same in both lots, and there appeared to be no advantage in hilling. The test was made upon poor clay loam.

8. *"Leggy" Plants*.—Drawn or so-called "leggy" plants usually give poor results in the field. It is a practice with some growers to bury the stems of such plants in a horizontal position, allowing only the vigorous tip to project above the soil, and it is sometimes said that badly drawn plants treated in this way give as early and as heavy crops as well grown plants. This point was tested upon a few plants of Potato Leaf. The plants were allowed to become drawn until they were two feet high and could scarcely stand alone. These were divided into two lots, one of which was set in the ordinary manner. The plants in the other lot were set three inches deep and then bent down to the ground and about a foot of the stem was buried, leaving ten or twelve inches of the top erect. A comparison of the two lots is given below :

TABLE X.—"LEGGY" OR DRAWN PLANTS.

SAMPLES.	Date of first picking.	Average no. of fruits per plant.	Average wt. of fruit per plant, lbs.	Average wt. of individual fruits, Ozs.
Ordinary Setting.....	Sept. 3	26.6	7.8	4.6
Deep Setting.....	July 6	31	8.1	4.2

It will be seen that the deep setting gave better results in earliness, number of fruits to the plant and weight of crop. The deep setting gave even two months' gain in earliness.

It will be interesting to compare these figures with the yields of normal plants of this variety. Average plants of Potato Leaf yielded as follows last year up to September 24, when they were destroyed by frost :

Average no. of fruits per plant.	Average wt. of fruit per plant. Lbs.	Average wt. of individual fruits. Ozs.
27-32	9.2	5.4

This shows that the normal well-grown plants give much better results than leggy plants, even when the latter are set deep ; and if the season last year had allowed of a picking in October, as it did this year, the superiority of normal plants would have appeared to still greater advantage.

It is therefore evident that every care should be taken to grow plants stocky and strong. This is done by giving the young plants plenty of room, air and sunlight. All over-crowding in the seed-boxes especially should be avoided. The first "handling" or transplanting should be done while the plants are yet in their second or third true leaf and before they become slender and weak. We sometimes shear off the tops of vigorous tomato plants after they have been transplanted once or twice if they are likely to become too tall ; and this shearing answers for one shifting.

9. *Products of Early and Late Fruits.*—It is everywhere thought that seeds from early fruits give earlier crops than seeds from late fruits,—that the character of the individual fruits, in other words, determines to a certain extent the character of the seedlings from them. Eight leading varieties were selected last year upon which to try an experiment involving the above questions. Seeds were saved from fruits which reached maturity August 5 and again from those ripe September 17. Plants from the two lots were grown side by side, and they behaved as indicated in the table :

TABLE XI.—PRODUCTS OF EARLY AND LATE FRUITS.

SAMPLES.	Date of first picking.	Average no. of fruits per plant.	Average wt. of fruit per plant. Lbs.	Average wt. of individual fruits. Ozs.
<i>Atlantic.</i>				
First picking.....	Aug. 29.....	33.6	6.6	3 2
Last picking.....	Aug. 29.....	51.1	15.9	4.9
<i>Brandywine.</i>				
First picking.....	Sept. 3	18.5	8.4	7.3
Last picking.....	Sept. 3	21.7	6.8	5
<i>Ruby.</i>				
First picking.....	Aug. 24.....	34 5	10.7	5
Last picking.....	Aug. 24.....	37.7	10 3	4.3
<i>Lorillard</i>				
First picking.....	Sept. 11	20.1	5.8	4.6
Last picking.....	Aug. 29.....	17	5.1	4.8
<i>Matchless.</i>				
First picking.....	Sept. 2	17	5.7	5.4
Last picking.....	Sept. 3	21	7.3	5.5
<i>Prelude.</i>				
First picking.....	Aug. 3.....	68.8	8.6	2
Last picking.....	Aug. 24.....	81.1	9.5	1.9
<i>Puritan.</i>				
First picking.....	Sept. 3	31.1	8.3	4.3
Last picking.....	Aug. 24.....	30.3	9.1	4.8
<i>Volunteer.</i>				
First picking	Aug. 24....	22	5.8	4.2
Last picking.....	Aug. 29....	35.1	11.5	5.2

Average number of fruits per plant from total first pickings 30.7
 " " " " " " last pickings 36 9
 Average wt. of fruits per plant from total first pickings 7.5 lbs.
 " " " " " " last pickings 9.4 "
 Average wt. of individual fruits from total first pickings 4.1 ozs.
 " " " " " " last pickings 4.6 "

In earliness there is no constant difference between the samples, but in yield the late fruits show, on an average, a considerable gain over the products of early fruits. This gain from the late fruits amounts to over 20 per cent. in number of fruits and 25 per cent. in weight of crop, and the weight of individual fruits

shows an increase. In the individual varieties there are only two instances in which the weight of crop from the early fruits exceeded that from the late ones, and even here the differences are not great.

This investigation was begun in 1888 at the Michigan Experiment Station, at which time 58 varieties were planted in duplicate sets from early and late fruits. In this instance the first picking comprised the first fruits which the variety matured, and the late picking was taken two weeks later. The results are given in detail in a bulletin of that station.* It was found that the early, angular sorts, like Hundred Day, Hubbard and Tom Thumb, gave earlier crop when grown from the first fruits, the first pickings from these samples being over four times heavier than from the same picking of samples grown from the later seed. With the common round or apple-shaped sorts, however, like Acme, the result was reversed, the first picking giving only two-fifths as many from the early-fruit samples as from the others.

The results of all these experiments are too much unlike to warrant many definite conclusions, but it appears to be safe to say that little if anything is to be gained by selecting seeds from first ripe fruits with no consideration of the character of the plant which bears them. In other words, there is good reason to believe that we should select because of some character of the plant as a whole rather than because some individual fruit may chance to please us. It is better to select from a plant which habitually bears early fruits than from one which bears only one or two early fruits among many mid-season or late ones. This proposition was insisted upon in our tomato report of last year in connection with productiveness and general improvement.

10. *Fruit rot.*—Tomato rot can be kept in check by the timely use of Bordeaux mixture,† but growers have always felt, and with good reason, that much of the injury can be avoided by judicious handling of the plants. The rot is usually worst in this latitude in late August and early September, and early plants are often able to give several good pickings before rot comes to be serious. The small tomatoes, like the Plum and Cherry sorts, are not injured

*L. R. Taft, Bull. 48, Mich. Exp. Sta. pp. 11, 17-26.

†See Dept. Agr. Rep. 1889, 418.

by rot, and the old fashioned angular sorts are not often attacked. It appears to be true that any system of cultivation which allows the ground under the vines to remain wet tends to augment the rot. Most growers say that heavy applications of stable manure increase rot, probably both because the manure makes a heavy and dense growth and also tends of itself to keep the ground moist. We once found that a mulch of clean straw increased injury from rot. Any system of training which allows free access of air and sun to the fruits and holds the plants above the ground appears to decrease rot. This was well shown in our single-stem training this year, in which there was only 5 per cent. of rot as compared with 50 per cent. on the same varieties on contiguous rows in which the plants were allowed to lie naturally. A friend who tried this experiment found no immunity from rot, but he failed to pinch out the branches and the trellis became an interminable mass of foliage.

It is often said that weak plants are more susceptible to the attacks of fungi than strong ones. This point was tested upon a small number of Ignatum plants. One lot was transplanted three times and the plants were in excellent condition when set in the field. The plants also had two heavy applications of Bradley's vegetable fertilizer. The other lot had but a single transplanting and the plants were weak and poor when set in the field; and they had no fertilizer. The two lots were set side by side. The strong plants gave double the yield of the weak ones. In the strong plants, 43 per cent. of the fruit rotted and in the weak plants 74 per cent. We dare not draw conclusions from this one experiment, but the results are in line with a popular notion. Observations for rot were made upon the early and late setting experiment (page 149), and it was found that 36 per cent. of the crop from the late setting rotted, against 44 per cent. from the early setting. It is impossible to say if this difference is chargeable to time of setting and consequent character of plant, or if it is a merely incidental variation. Repeated trials must determine this. But whatever value may attach to these figures, it is clear that upright and open training tends to decrease injury from rot; and it may also be said that such training allows of more easy and thorough treatment if spraying is necessary.

11. *Keeping Qualities of Tomatoes.*—The commercial value of a tomato is in part determined by its keeping qualities, and it is important to know if these qualities are corellated with solidity, varietal differences, or other characters. We have made some studies in this direction. Our first and most extended observations were made in 1889, and as the results have never been published they are inserted here. A number of well ripened sound fruits of many varieties were laid upon a dry bench in a long forcing-house, September 4. They were examined frequently, and fruits were removed as soon as they began to decay. The forcing-house was very hot under a bright September sun, but all the samples were subjected to the same conditions. A numerical review of the record is given below :

TABLE XII.—KEEPING TEST, 1889.

VARIETY.	Whole no. fruits Sept. 4.	No. de- cayed Sept. 10	No. de- cayed Sept. 13	No. de- cayed Sept. 17	No. de- cayed Sept. 25	No. de- cayed Sept. 30	No. de- cayed Oct. 5.	No. de- cayed Oct. 8.	No. not de- cayed Oct. 8.
Acme.....	8	0	4	3	1				
Advance.....	11	1	3	2	4	0	1		
Alpha.....	9	1	5	1	1	1			
Amber Gem.	6	0	2	3	1				
Atlantic.....	7	0	3	1	2	0	1		
Autocrat.....	7	2	4	1					
Beauty.....	8	1	1	2	4				
Belle.....	10	2	1	7					
Bermuda.....	7	1	3	2	0	0	1		
Brandywine.	5	0	0	4	1				
Canada Vic..	6	0	2	2	1	0	1		
Cardinal.....	11	1	3	2	1	3	1		
Conqueror ...	8	1	2	1	0	1	3		
D. Champion	8	0	3	3	2				
".....	7	0	1	5	1				
Favorite.....	4	0	2	0	1	1			
".....	5	1	1	0	2	1			
Golden Rod..	4	0	1	1	2				
Gold. Queen	7	1	1	1	2	2			
Grant.....	8	2	4	0	2				
Green Gage..	11	1	0	6	2	1	1		
Hathaway ...	4	1	2	0	1				
Hovey.....	10	1	1	3	4	1			
Hundr'd Day	10	2	4	1	1	1	1		
Ignotum.....	29	4	2	14	9				
Jersey.....	4	1	1	1	0	1			
Jones.....	5	0	2	1	2				
Jones' Thirty	7	0	0	2	5				
King (<i>K. of the Earlies</i>)	12	1	2	4	1	3	0	1	
K. Humbert.	6	1	4	1					

TABLE XII.—KEEPING TEST, 1889.—*Concluded.*

Variety.	Whole no. fruits Sept. 4.	No. de- cayed Sept. 10.	No. de- cayed Sept. 13.	No. de- cayed Sept. 17.	No. de- cayed Sept. 25.	No. de- cayed Sept. 30.	No. de- cayed Oct. 5.	No. de- cayed Oct. 8.	No. not de- cayed Oct. 8.
Large Yellow	9	2	2	4	1				
Large Yellow Improved..	11	0	2	0	3	3	2		1
Little Gem.....	10	1	3	1	2	1	1		1
Lorillard.....	10	0	3	2	3	2			
McCullom ...	11	0	7	0	4				
Market									
Champion	6	0	2	1	1	2			
Optimus.....	7	0	1	3	1	2			
"	11	1	2	2	3	1	2		
Peach	10	0	1	5	2	2			
Perfection ...	5	0	0	1	2	2			
"	7	0	0	0	7				
Potato Leaf..	6	0	1	4	1				
Prelude.....	10	0	2	2	2	2	1		
Puritan.....	4	0	2	1	1				1
Queen	5	0	3	1	0	1			
Red Apple....	11	1	2	6	2				
Salzer.....	6	0	6						
Scoville	4	0	1	2	1				
Shah	6	3	0	1	1	1			
Tilden	9	0	0	0	3	5	1		
Tree	13	0	2	4	6	1			
Trophy	12	0	3	1	5	3			
Volunteer....	4	0	0	1	1	2			
"	4	0	0	1	2	1			
"	6	0	0	3	3				
White Apple	7	0	0	3	0	3	1		

The table comprises 56 entries and 50 different varieties. Six days after the tomatoes were placed in test, 24 varieties had rotten fruits, and of one, the Shah, 50 per cent. were lost. These 24 varieties represent all the types of tomatoes under trial, from the little Green Gage to the large and solid Ignatum. Three days later 23 more varieties had begun to decay, while the Shah, of which 50 per cent. had rotted at the first inspection, showed no further decay, and there was also no further decay in Green Gage. Four days later, or thirteen days from the beginning of the experiment, seven other samples which had not before shown decay, contained rotten specimens, as follows: Brandywine, Jones' Thirty, one sample of Perfection, the three samples of Volunteer, and White Apple. Two varieties, one of the Perfection samples and Tilden, gave no decayed specimens until September 25, or three weeks after the trial began. September 30, after the expiration of 26 days,

15 varieties still had a few sound fruits. Of these 15, nine had given rotten fruits at the expiration of six days, showing that there had been no uniformity in the keeping qualities of those samples. October 5, a month after the beginning of the test, four varieties still possessed sound fruits: King, Large Yellow Improved, Little Gem, and Prelude. Two of these had rotten fruit six days after the trial began and all had begun to decay at the expiration of nine days. Three of these, Large Yellow Improved, Little Gem, and Prelude, had a single sound but shrivelled fruit October 8th, when the test was concluded. The varieties which kept the longest, therefore, were the small and little valued ones, while the Ignatum, which is perhaps the most solid variety of the lot, was all gone at the expiration of three weeks, and this, too, in spite of the fact that over twice as many fruits of it were under observation, thus increasing its chances of embracing extra sound individuals. But the commercial measure of keeping qualities is not so much the length of time which a few odd fruits will keep as the time which all the fruits will keep. Considered in this light, the best keepers were those which showed no rotten samples until the expiration of three weeks, the Perfection and the Tilden, and the five which showed rot only on the thirteenth day: Brandywine, Jones' Thirty, Perfection, Volunteer, and White Apple. It is strange that the White Apple should have been among the longest keepers, for it is a soft fruit; it would appear to indicate, along with the comparatively short life of Ignatum, that keeping qualities are not associated with solidity: and if they are not associated with solidity, then they can not be associated with good shipping qualities. The figures also show that those varieties which begin to rot quickly may at the same time contain samples which keep a long time. The Shah, for instance, of which half had rotted at the expiration of six days, was not all gone until 26 days, or after the entire disappearance of some kinds which had shown no rotten fruits at six days. This fact, taken in connection with the general irregular behavior of most of the samples, leads to the conviction that the length of time to which a fruit will keep is largely accidental to the fruit in the best varieties: that is, that keeping quality is comparatively undeveloped as a varietal character in the tomato.

A similar keeping test was made this year upon a smaller

scale. Fifteen varieties were picked September 25 and placed in a cool dry room into which no sunlight enters. The record is as follows :

TABLE XIII.—KEEPING TEST, 1891.

VARIETY.	Whole no. fruits Sept. 25.	Condition Sept. 27.	Condition Oct. 14.
Bon Ton.....	4	1 decayed.....	1 sound.
Dwarf Champion.....	4	All beginning to rot..	All gone.
400	3	2 decayed.....	1 beginning to decay.
Golden Queen.....	4	Sound	1 sound.
Ignotum.....	3	Sound	All beginning to decay
Ithaca	3	Sound	All gone.
King (<i>K. of the Earlies</i>).....	4	Sound	2 sound but shrivelled
Long Keeper.....	2	1 decayed.....	1 nearly sound.
Lorillard.....	4	1 decayed.....	All beginning to decay
Mikado	4	All beginning to rot..	All gone.
Peach	3	Sound	All beginning to decay
Ruby Queen.....	3	Sound.....	All decayed.
Station*.....	4	2 decayed.....	2 remaining beginning to rot
Stone.	3	1 decayed.....	1 sound.
White Apple	6	Sound.....	4 sound.

*The form closely resembling the Tree tomato.

Here again the small and unimportant varieties kept longest, the White Apple and King making the best record. The Peach is also one of the best. This fact is interesting in connection with the observation that the fruit-rot in the field rarely attacks the small and little improved varieties. Of the large varieties, the Ignotum made the best record, although in the test of 1889 it was not one of the best. But as in the other trial, there appears to be little long keeping quality which can be associated with varietal differences.

12. *Do Fertilizers Modify Quality?*—It is a common opinion that the tomato is considerably modified in quality by different soils or fertilizers. In order to investigate this point we had chemical analyses made of representative fruits from various experiment plots. The samples in the following table are all Ignotum :

TABLE XIV.—QUALITY OF TOMATOES.

SAMPLES.	Solids. Per cent.	Sugar. Per cent.	Malic acid. Per cent.
1. Sandy loam and stable manure.....	4.92	3.89	.80
2. Nitrate of soda on clay loam (Table III plot 1).....	6.02	5.12	.76
3. Muriate of potash (plot 3).....	5.97	4.97	.68
4. Nitrate of soda and bone black (plot 4).....	6.00	5.07	.70
5. Nitrate of soda and muriate of potash (plot 5).....	5.93	4.92	.68
6. Bone black and muriate of potash (plot 6).....	5.90	5.08	.71
7. Bone black and muriate of potash (plot 6).....	5.86	4.89	.71
8. Nitrate soda, bone black, muriate pot- ash (plot 7).....	6.04	5.01	.77

It is noticeable that the percentage of sugar is lowest in sample 1, or the stable manure treatment, and the percentage of acid is highest. This sample, therefore, may be considered the poorest in quality. Among the other samples the variation is not great, although the nitrate of soda sample, No. 2, gives a conspicuously larger percentage of sugar, but at the same time a rather high percentage of acid. It is to be observed, also, that samples 6 and 7, taken from contiguous plants on the same plot, show a considerable difference in the amount of sugar. But the general differences in results are not sufficiently marked and constant to warrant any definite conclusions, although one is led to feel that there is little variation in flavor due to fertilizer; and the uncertainty is further increased by the fact that only one fruit was analyzed from each plot. Experiments in Maryland* seem to indicate that potash increased the acid and phosphoric acid "produced some of the sweetest tomatoes found."

13. *Crosses*.—Last winter a few successful hybridizations were made between the Ithaca and Currant tomatoes. The former is a round or apple-shaped tomato of the common *Lycopersicum esculentum* type, while the latter is a distinct species, *L. pimpinellifolium*. The two plants are widely dissimilar in habit and botanical characters. The Currant tomato is a long and weak grower

* Bull. 11, Md. Exp. Sta. 73.

with a thin and delicate foliage, small flowers in two-sided racemes of from 10 to 20, and firm round red fruit little larger than a large Cherry currant. The leaflets are usually small, rounded at the base, entire or obtusely toothed, mostly rounded at the apex; and the leaf bears many small and rounded intermediate leaflets. The character of the foliage of the Currant is well shown, half size, in the sprig of a leaf in the upper left hand corner of Fig 1. The character of the Ithaca foliage is shown at the bottom of the cut. The flower buds of the currant are slender and tapering above, or spindle-shaped, and the calyx lobes are so small that the petals and style protrude beyond them, giving a pointed apex to the bud. In the common tomatoes the calyx lobes are longer and cover the inner organs in the young bud. It was a comparatively easy task to hybridize the Ithaca with the Currant, but we did not succeed with the reciprocal cross, although many attempts were made. These crosses were made in the forcing-house.

The hybrids were all uniform in character and were almost exactly intermediate between the parents. Fig. 1 shows a cluster of fruit and a leaf of the hybrid one-half diameter and a fruit natural size, and also sprigs of the leaf of Currant and Ithaca. The intermediate character of the foliage is well shown in the illustration. The flowers in the hybrid have calyx lobes considerably longer than those of the Currant, so that the flower buds are much less prominently pointed than in that species. But the fruit is the most interesting feature to the horticulturist. The cluster shown in Fig. 1 is an average one. It contains ten good fruits, all ripe at the same time, but some of the clusters produced as high as fourteen, and a few as low as six and seven. There was, therefore, a very great gain in number of fruits over the Ithaca, from which the seeds had come. The fruits were also four times larger than in the Currant. In other words, the Currant had contributed much of its size of cluster and the Ithaca much of its size of fruit. The plants were very handsome with their clusters of deep red fruit from six to eight inches long, and they at once suggested to all observers the possibility that a new race of tomatoes might be developed from the cross. In a practical way, it is impossible to say what may come of this new hybrid, but we are now endeavoring to cross the hybrid with the Ithaca and the Ithaca with the hybrid in the hope that we may still



FIG. 1.—Tomato Hybrid (*Lycopersicum esculentum* × *L. pimpinellifolium*).
 Leaves of the parents are shown at the top and bottom. The detached
 fruit is natural size.

further increase the size. The fruit at present is of the size and appearance of a large Cherry tomato, but the long clusters, and particularly the peculiar foliage, at once distinguish it.

We have long desired to secure a yellow tomato with a permanent red cheek, and many attempts have been made to secure it. One of our attempts has been a cross between the Golden Queen and Ignatum,—yellow and red varieties—the latter being the staminate or male parent. This cross was made in the open last year by C. W. Mathews, a senior in agriculture. Offspring was grown in the house last winter and the fruit was indistinguishable from pure Ignatum, being uniformly dark red in color. Plants were also grown in the field this summer and the fruits were the same as in the house. Professor Munson, of the Maine Agricultural College, also grew some of the plants in the field from our seeds with results the same as our own. It is strange that seeds from a yellow fruit should uniformly produce red fruits, but the fact is unimpeachable; and additional confirmation of it is afforded by the spontaneous mixing in the field, as recounted below.

Another of Mr. Mathews' crosses was between the Mikado, pistillate, and Ignatum, staminate. In this case, also, the parents were very dissimilar. The Mikado bears a purple fruit and the Ignatum red. The Mikado has very large leaves with nearly entire leaflets and few or no intermediate or small leaflets, while the Ignatum foliage is like that of most common tomatoes. Fig. 2 shows representative leaves, half size, of the parents and the cross. No. 3 is the Mikado and No. 2 the Ignatum. No. 1, the cross, is exactly intermediate. The leaflets are much less cut than in the Ignatum, and the intermediate leaflets are mostly absent, giving the leaf an open or spreading appearance. This type of foliage is conspicuous in the field, and it is the same as the foliage of Ruby Queen, the peculiarity of which was unintelligible before we had made this cross. The fruits were uniformly red like the Ignatum, both in the house and in the field. These crosses were very productive and attractive.

14. *Do Tomatoes Mix in the Field?*—For several years we have observed that occasional plants in a tomato field bear fruits not "true" in color, size, and shape. It has been our habit to attribute these "rogues" to mixing of the seed in handling, but these plants appear in seeds of our own saving where every care



FIG. 2.—A Tomato Cross.—1, *The Cross*. 2, *Ignotum*, staminate parent.
3, *Mikado*, pistillate parent.

has been exercised to keep the seeds separate. The feeling grew upon us that some, at least, of this untrueness to type must be due to crossing. In 1890, therefore, we sought to test the matter. Two or three plants of each of six varieties were set closely together in a row, all the plants of each variety being together. The varieties and the order were as follows :

1. Potato Leaf. 2. German Raisin. 3. Golden Queen. 4. Favorite. 5. Jaune Grosse Lisse. 6. Mansfield Tree

These represent widely different varieties. The Potato Leaf has very large Mikado-like leaves and purple fruit. The German Raisin is the same as Currant and belongs to the species *Lycopersicum pimpinellifolium*. Golden Queen and Jaune Grosse Lisse are yellow, Favorite red and Mansfield purple. Several fruits were saved from each variety and this year a few plants were grown from them. The following record shows what took place :

1. Potato Leaf.—14 plants. 13 typical Potato Leaf, but one hybridized by German Raisin. This one crossed plant bore red fruits about three times larger than German Raisin, had much the general habit of that variety, and the foliage was almost exactly intermediate between the two, having very much the form of the hybrid shown in Fig. 1. The fruits were borne in long clusters of eight or ten.
2. German Raisin.—9 plants. 8 typical German Raisin, but one clearly a hybrid with some large tomato, probably either Potato Leaf or Golden Queen. This plant bore red fruits twice larger than normal, and the foliage was a strange intermediate between this species and the common tomatoes. It was small and sparse, but nearer the common tomatoes in form and texture. Thus a spontaneous hybrid was produced with *Lycopersicum pimpinellifolium* as its pistillate parent, but we had not succeeded in making this cross artificially. A chemical analysis of a number of fruits of these hybrids gave the following indications of flavor :

Solids, 5.86 per cent. Sugar, 4.92 per cent. Acids, .69 per cent.

Comparing these figures with Table XIV., it will be seen that the composition is not essentially different from that of ordinary tomatoes.

3. Golden Queen.—13 plants, of which 11 were true. 2 were

clearly hybrids with German Raisin. The fruits were deep red, the same as German Raisin, although the seeds came from yellow fruits. The foliage was intermediate, very like that shown in the hybrid in Fig. 1.

4. Favorite. — 15 plants, all true.
5. Jaune Grosse Lisse. — 15 plants of which 14 were true to type, being large and bright yellow. One plant, however, bore large light red tomatoes, indicating a cross with a red variety.
6. Mansfield Tree. — 15 plants, 14 bearing normal purple fruits. One plant, however, bore red fruits like Favorite.

These records are interesting and valuable because they show that mixing occurs spontaneously in the field. It would be an interesting study in probabilities to calculate how many plants untrue to type might have appeared if all the seeds from the plants had been used, instead of from nine to fifteen. In all the crossing studies it is interesting to note that red varieties never produced purple or yellow fruits, while both purple and yellow fruits produced red ones.

15. *Do Varieties of Tomatoes run out?*—For some years it has been apparent to the writer that varieties of tomatoes run out or lose their distinguishing characters. The reasons for this loss of varietal character it is not necessary now to discuss. Crossing no doubt hastens it in many cases. But it is well to state that running out does not mean deterioration simply, but disappearance of characters by whatever cause.* Studies of this question were made this year by growing the same variety from many seedsmen. This gave us an opportunity to determine if the variety had varied greatly in the course of its history, or if all seedsmen really sold the same thing under a given name. In order to determine how long a variety may persist we selected Grant and Canada Victor, which are old varieties; and to find out how soon a variety may depart from its type we grew the Ignotum.

Grant was obtained from seven seedsmen,—all who catalogued it. Of these seven samples, but two were true Grant as the variety was recognized a few years ago. In these two, the fruits were

*"It is a common but erroneous notion that 'running out' necessarily means deterioration." Bull xxi. Cornell Exp. Sta. 83.

wrinkled and flattish, somewhat angular, and yellowish about the stem. The remaining five samples gave fruits of various kinds, although somewhat resembling the Grant type. Some of the samples gave two or three distinct types of fruit. One of the samples bore only a few small and shapeless fruits which were entirely worthless. Some plants bore small and nearly smooth fruits not unlike an overgrown Cherry tomato. One lot gave fruits superior to Grant. They were large and regular, much like Volunteer but flatter. The plants in this sample were robust. This had undoubtedly been bred away from the Grant by selecting for largest and smoothest fruits. All the other samples were inferior to Grant. It may be said that these variations were due simply to mixing of the seeds during a number of years by careless handling, but there is reason to suppose that such is not the case. The Grant has a peculiar small, slightly curled light colored foliage and a well marked upward habit of growth of the young shoots. These characters appeared constantly in all the samples. The foliage, being less variable than the fruit and not an object of selection by the horticulturist, had remained constant, while the fruit had lost its characters.

Canada Victor was grown from ten seedsmen. There were none which could be recognized as true Canada Victor, but they were all small, variable, irregular and practically worthless. Some plants bore small and nearly globular fruits, much like large Cherry tomatoes, and some were thick-walled, suggesting the old Criterion. Yet in all the samples, the peculiar slightly curled foliage of Canada Victor was apparent.

Ignotum was obtained from fifteen dealers. This variety was first offered by seedsmen in 1890. Of the fifteen samples, eight gave small and poor fruits which were not worth growing and could not be recognized as Ignotum by any character. The other samples were fairly uniform and represented a medium type of Ignotum. Ignotum grown from one of our own savings gave a number of plants which bore inferior fruits, although clearly Ignotum. It is difficult to suppose that in one season a variety could so far have lost its characters that one-half the seedsmen should offer inferior stock of it. The variety is well fixed, for in one of our large plantations of it, it was remarkably uniform and equally as good if not even better than two years ago. We have

been curious to note the reports of Ignotum which have come in from various parts of the country, for knowing its history we may be able to discover some facts in the variation of plants. Most of the reports speak well of it, but now and then a grower finds it inferior. A correspondent in New Jersey sends the following account of it :

"It is very smooth and productive, bright in color, ripening up to the stem, and with me that is all that can be said in its favor ; it is small as compared with the Matchless ; it is not solid but hollow and full of seeds ; worst of all it has a tendency toward



FIG. 3.—*Old and New Types.*

black heart. I could not find one in ten of my entire crop but was afflicted with this hard black core." It is strange that such a condition should exist so early in the life of a variety, and it would be interesting to know if it is a case of running out or of mixing or substitution of seeds.

16. *Impressions of Varieties.*—Several good tomatoes have been introduced this year. The tendency is towards the apple-shaped or round regular types. The day of the flat and angular tomatoes appears to be past. It was not many years ago when the common type of the tomato was very like the smaller outline in Fig. 3. To this type belong such old favorites as Orangefield, Hundred Day, Conqueror, Large Red, Precursor, Hubbard, Keyes and Tom Thumb. These have almost entirely passed away, and the Paragon-like fruits, of the form of the larger outline in Fig. 3, have taken their places. With this change in fruit has come

a decided change in foliage and somewhat also in habit of plant. The angular sorts usually had a small and more or less curled light colored foliage and a low growth. The newer sorts possess a plane and very luxuriant foliage. And of late years, too, the large-leaf type, like the Mikado and Potato Leaf, has come in ; and strangely enough an intermediate between the last two now appears in Ruby Queen, evidently a result of crossing (see page 168). Our impressions of the new and some of the less recent introductions are given below :

Atlantic. (*Atlantic Prize.*) One of the earliest and best Fruits rather larger than in 1890 but more irregular. Our plants bear little after the middle of September. Red.

Bon Ton. (*Garretson*, 1891.) A large, firm purple tomato of promise. Plants vigorous and productive. Very like Acme and Beauty, but apparently not superior.

Brandywine. Fruits very large but generally irregular this year. Moderately productive. Appears to possess no superiority over similar sorts. Red.

Climbing. (Childs, 1891.) A variable tomato of small size and early, but of little value. Many of the fruits suggest the old Criterion, having an oblong shape, hard walls and large interior cavities. Some of them are pubescent and resemble the Peach tomato. There is nothing to suggest a climbing habit in the plants which we have grown.

Cumberland Red. (Johnson & Stokes, 1891.) A large red and usually regular tomato of much promise. It is productive, medium early.

400. (Henderson, 1891.) A pink tomato of enormous size. Our largest fruit weighed 2 lbs 10½ oz. The plants do not produce a great number of fruits, however. The season's record of 12 plants is as follows :

Date of picking.	Number of fruits obtained from 12 plants.	Weight of fruits.	Average wt. of individual fruits.
Aug. 3	1	10 oz.	10 oz.
" 24	6	3 lbs. 11 "	9.8 "
Sept. 3	2	2 " 4 "	1 lb. 2 "
" 11	7	5 " 8 "	12.3 "
" 18	25	16 " 8 "	10.6 "
" 25	46	22 " 12 "	8.0 "
Oct. 5	39	26 " 4 "	10.8 "
Totals	180	77 lbs. 9 oz.	11.3 oz.

This gives an average per plant of 15 fruits, of crop of 6.4 lbs., and the average weight of fruits is a little over 11 ounces. The total average productiveness is therefore comparatively low. A good average plant of the Lorillard, for instance, gave a total product of 50 fruits and over 13 pounds of crop, as seen in Table VII, and this yield is by no means uncommon in good varieties in this latitude. These figures are interesting as showing that further increase in productiveness in the tomato probably does not lie in augmentation of size of fruit.

This variety, 400, is very irregular, and not uniform in size. The great variation in size is shown in the above figures. The average weight of fruits was 11.3 ounces, while the largest was 2 lbs. 10½ ounces, or the difference between 11 and 42. The variety does not appear to possess much value.

Ignotum. This variety is still the best which we have ever grown, although in some instances it has shown a tendency to produce irregular fruits.

Ithaca. This variety appears to be valuable among the medium and regular sorts. It is productive, uniform, of good shape and color. Red.

Long Keeper. (Thorburn, 1891.) A good uniform pink or purple tomato of medium size, regular and productive. Apparently occupies about the same place among purple tomatoes that Ithaca does among red ones. Promising.

Mitchell. (Gregory, 1891.) Medium in size and season, regular, of good form, productive. The plants were not uniform and there is a tendency towards irregularity of fruit. A good tomato, but apparently not superior to some other sorts. Red.

New Zealand. (Wilson, 1891.) Very like the old Yellow Cherry, but a trifle larger and with a tendency to become irregular

Polomac. (Joseph Harris, 1891.) A purple variety very like smooth medium specimens of Mikado in fruit, but the foliage is that of the ordinary tomatoes. There is perhaps too great a tendency in the fruits to be furrowed about the base. Productive and promising.

Red Mikado. (Dreer, 1891.) A large red tomato, like good specimens of Mikado except in color. Foliage of Mikado. Promising.

Ringleader. (Dreer, 1891.) Fruits very large in size and shape much like the 400 of Henderson, but perhaps even more irregular. Apparently of no commercial value.

Station. This variety is the product of a cross between Upright or Tree and Alpha, made by E. S. Goff at the New York Experiment Station. It has given rise to many forms, all of which are interesting as showing the results of crossing. We grew it from three sources this year. Twelve plants were grown from seed raised in 1886 at the Geneva Experiment Station. The plants were all alike and were the same as Tree in foliage and habit. The fruits were red, medium, earlier than Tree, somewhat angled. Eleven plants were grown from Geneva seeds from crop of 1889, and they were like the above, with perhaps a greater tendency to regularity in the fruits. Eleven plants were grown from seeds sent us from E. S. Carman of the *Rural New-Yorker*. These seeds were from a strain bearing "sweet tomatoes, very solid, and which will keep longer than any other variety." The strain came from the first selection of Goff's cross. Of our 11 plants, four were like Tree in habit and foliage, bearing small and regular fruits. The others resembled common tomatoes in habit, but varied greatly in fruit. Some bore small pear-shaped fruits and some looked like the old-fashioned Cherry tomatoes. Some were like Prelude in size and shape—an inch and a half in diameter and nearly globular. None of them possessed any value.

Stone. (Livingston, 1891.) A good red solid tomato of medium, even size. Productive and attractive.

White Peach. Last spring E. S. Carman sent us seeds of a white sport of the peculiar Peach tomato. Twelve plants were grown, all of which bore whitish yellow fruits. Except in color, the fruits were like the Peach.

A cultivated tomato of Paraguay was sent us last year by Dr. Thomas Morong, a botanist traveling in that country. It is a handsome and productive, small yellow variety, indistinguishable in appearance from some strains of our Yellow Plum.

SUMMARY.

1. *Fertilizers.*—The best tomato fertilizers are those which produce their effects early in the season. The intermittent application of nitrate of soda, when prolonged into August, delayed the crop as a whole, while early applications appear to produce early results. But larger yields appear to follow intermittent application if it does not extend beyond mid-summer. (Page 143.)

2. *Nitrate of Soda.*—Nitrate of soda is an incomplete fertilizer and should not be used to the exclusion of other fertilizers unless the soil is already rich in potash and phosphoric acid. Upon poor soils it is of little advantage when used alone. (Page 146.)

3. *Relation of Variety to Fertilizing.*—Some of the variations in results of fertilizer tests may be due to some difference between varieties in the readiness with which they respond to treatment. In a limited test, improved varieties gave greater increase in number of fruits, but there was a decrease in weight of individual fruits; but the unimproved, while showing a less increase in number of fruits, suffered no loss in size, and consequently gave a greater proportionate gain in weight of crop. (Page 148.)

4. *Early and Late Setting.*—The experiments of two years show that tomato plants which are early set in the field, are less injured by inclement weather than is generally supposed, and that very early setting on well prepared land appears to be advisable. But the results of early setting, especially as regards earliness, probably depend considerably upon the character of the plants: they should be strong and stocky. (Page 149.)

5. *Few and many Transplantings.*—Two transplantings gave better results than three, but so much depends upon condition of

plants, their age, and the way in which they are handled, that generalizations cannot be made upon the subject. (Page 150.)

6. *Seedlings vs. Cuttings*.—Seedling plants have given better crops than cuttings of the same age during two seasons, but this year cuttings gave somewhat earlier fruits. (Page 151.)

7. *Trimming*.—Slight trimming or heading in of tomato plants gave good results last year, but indifferent results this year. The difference was due, apparently, to the fact that the trimming was performed too late this year. Trimming during July and early August appears to be beneficial. (Page 152.)

8. *Single-Stem Training*.—Single-stem training of tomatoes gave twice as much yield per square foot as ordinary culture, somewhat earlier results, and it greatly decreased injury from rot. The system is to be recommended for early market or choice trade or for home use. (Page 154.)

9. *Hilling*.—Hilling the plants resulted in no advantage. (Page 156.)

10. *"Leggy" Plants*.—"Leggy" or badly drawn plants may produce a fair to good crop when set deep and a large portion of the stem buried, but they do not appear, even then, to be equal to stocky plants. (Page 156.)

11. *Products of Early and Late Pickings*.—Little, if anything, appears to be gained by selecting seeds from first ripe fruits with no reference to the character of the plant from which they come. (Page 157.)

12. *Rot*.—Upright and open training tends to decrease injury from rot; and such training allows of more easy and thorough applications of fungicides when spraying is necessary. (Page 159.)

13. *Keeping Qualities*.—As varieties depart from their earlier or unimproved types, there appears to be some loss in keeping quality. But keeping quality does not appear to be correlated with solidity or associated with varietal differences, and is not associated, therefore, with best shipping qualities. Keeping quality is comparatively undeveloped as a varietal character in the tomato. (Page 161.)

14. *Hybrids*.—A hybrid between Ithaca and Currant was intermediate between the parents, and produced fruits four times the size of the Currant in clusters of from six to fourteen. (Page 165.)

15. *Crosses*.—Crosses between yellow and red tomatoes, the

yellow being the pistillate or seed parent, uniformly gave red fruits; and crosses between purple and red varieties also gave red fruits. (Page 168.)

16. *Crosses*.—Crosses between the large-leaf and common type of tomatoes (Mikado and Ignatum) gave foliage of a peculiar type intermediate between the two; and this peculiar foliage is also a characteristic of Ruby Queen. (Page 168.)

17. *Do Varieties Mix?*—Tomatoes mix in the field, and even hybrids with the Currant type of tomato may arise spontaneously. Red tomatoes sometimes come from yellow and purple fruits. It is therefore evident that seeds should be selected from plants which are somewhat removed from other varieties. (Page 168.)

18. *Running Out*.—Tomatoes run out or lose their distinguishing characters. Even the most popular varieties of ten years ago are not often obtained true to type at the present time. In well marked varieties of recent introduction great dissimilarity may exist between stocks from different seedsmen, but it is not certain that all this variation is chargeable to running out of the variety. Many inferior stocks of Ignatum, introduced in 1890, are now on the market. (Page 171.)

19. *Varieties*.—The Ignatum is the best variety for all purposes which we grew this year. Among the introductions of the year, the following are the most promising: Cumberland Red, Long Keeper, Mitchell, Potomac, Red Mikado, Stone. (Page 173.)

L. H. BAILEY.

E. G. LODEMAN.

II. 1886-1891.

Six years ago an investigation was projected for the purpose of studying various points in the amelioration and cultivation of the tomato. At that time the plant had received little scientific attention. It was thought that ten years would be ample time for the completion of the investigation. But at this time the horizon has widened, and it is plain that a lifetime must be spent upon the plant. A few things have been learned meantime, and some of the most prominent of them are here collected. There may be little of value in them, but they may suggest to other students some useful lines of inquiry.

One is sometimes interested to trace the progress of his own habit of thought upon a given subject. In 1887 the determination of synonymy of varieties appealed to me strongly, and the following statement was made of its purpose: "The determination of the duplicates among the many so-called varieties of the tomato is one of the most obviously practical problems connected with this experiment, and one which has received much attention. There is probably no garden plant which is so difficult to study in this respect as the tomato, from the fact that varieties are characterized almost entirely by the color, size and shape of a fruit which is of all others the most variable. Moreover, the tomato has been in general cultivation so short a time that varieties are not yet fixed. Add to these facts the hasty and bungling methods or lack of method of seedsmen and others in securing the so-called new varieties, the wide variations of the same varieties on different soils and under different managements and the frequent mixing of stocks by careless parties, and the task of determining duplicates appears to be almost hopeless. But the very difficulty of the task is all the more reason why it should be grasped. This whole matter of determining the synonymy or the duplicates in cultivated plants, together with the reformation of garden nomenclature, is exceedingly important. None are so well qualified to undertake this work as many of our seedsmen and it seems strange that they should be the very ones who make this work necessary. The time can certainly not be far distant when the most popular seedsmen will be those who exercise the most care in excluding 'novelties' and unnecessary varieties."

At the present time I should consider this feature of the study of tomatoes as of decidedly minor importance ; and even then it was not considered to be of chief consequence, as the following paragraph may show :

"Yet, notwithstanding the apparent importance of determining synonyms or duplicates, there are other far more important features of this study of varieties of garden plants. We need to determine the general characteristics and tendencies of the existing varieties, in order to make any safe venture towards improvement. Again, this system of comparing varieties, of sorting, emphasizes the good and bad qualities of each variety, and at once establishes a standard of excellence. To sort our varieties is more important than to sort the fruit for shipment, for its value, influence, extends over many seasons. Thus it becomes apparent that even if the determination of duplicates, as recorded in the following pages, is not always correct, there is yet a broad and deep value in this system of comparison."

The study of synonymy led at once to some system of classification and description, however, and thus served the investigation a useful purpose.

I. CLASSIFICATION, DIRECTION OF VARIATION, ETC.

Classification.—The common tomato species, *Lycopersicum esculentum*, may be divided into five primary divisions : the cherry tomatoes (variety *cerasiforme*), plum and pear tomatoes (var. *pyriforme*), the common market tomatoes (var. *vulgare*), the large-leaf kinds like Mikado (var. *grandifolium*), and the upright or tree sorts (var. *validum*). The common tomatoes (var. *vulgare*) can again be divided for purposes of classification into three sub-divisions : the oblong, angular and apple-shaped tomatoes. The currant tomato is a distinct species, *Lycopersicum pimpinellifolium* or "pimpinella-leaved tomato." In tabular form, the classification of the tomato may stand, therefore, as follows :

I. *Lycopersicum pimpinellifolium*. This has not yet varied to any extent in cultivation, and the one variety is known as the Currant and German Raisin.

II. *Lycopersicum esculentum*. The parent of all commercial tomatoes.

A. Var. *cerasiforme*. Cherry tomatoes, characterized by slender growth and small light-colored foliage, and small globular fruits

which are normally 2-celled. Red and yellow varieties are known.

B. Var. *pyriforme*. Pear and plum tomatoes, distinguished from the preceding sub-division chiefly by the more or less pear-shaped pendant fruit. Red and yellow varieties are known. The Nesbit's Victoria has foliage much like that of Section D.

C. Var. *vulgare*. The common tomatoes.

1. Oblong tomatoes. Fruit as long or longer than broad, the walls very thick and firm, the placentæ usually not meeting the inside of the wall, causing the fruit to feel as if hollow. Red and purple varieties are known. Represented by King Humbert and Criterion.

2. Angular tomatoes. Fruit medium or below in size, mostly very flat, plane on top, more or less cornered, the lobes most conspicuous on the bottom and sides. This is the type of the original Large Red, the first market tomato. The type is almost lost in many of our later improvements, and it is now too inconstant, perhaps, to be relied upon as a sectional character. The angular tomatoes are practically out of cultivation in this country. See Fig. 3. In many of the varieties the leaves are singularly curled. Only red varieties are known, but many of them are very light or orange-red, and one, the German Gestreifte, is striped with orange.

3. Apple-shaped tomatoes. Fruit various in size or shape, but in normal forms more or less rounded on top, the monstrous or overgrown specimens developing a scar-like line or ring on the top and the ends of the fruit turning downwards. These comprise by far the larger number of the tomatoes of the present time. See Fig.

3. Some of the varieties, like Green Gage, Peach, and White Apple, are much like the Cherry tomatoes (var. *cerasiforme*) and should, perhaps, be classed with them. Red varieties predominate, but purple, yellow and white varieties exist.

D. *grandifolium*.—Large-leaf tomatoes. Habit and fruit as in section C; leaves very large; leaflets fewer than common (about two pairs), large (the blade three to four inches long and an inch and a half wide), entire, the lower side strongly decurrent. Leaves of the young plants entire! The terminal leaflet is often six inches long and four or more inches broad.

Represented by Mikado, Puritan, Shah, and others. The first of the well marked *grandifolium* varieties were purple, but a yel.

low one is grown and this year a red one (Red Mikado) has appeared.

E. validum.—Upright tomato. Stem very thick and stout, the plants nearly sustaining themselves, two to two and a half feet high; leaves very dark green, short and dense, the leaflets wrinkled and more or less recurved. An odd plant with much the aspect of a potato plant.

Represented by the French Upright or Tree, which has red fruits. The Dwarf Champion is perhaps a cross between this type and the common tomatoes. The Station tomato, which is a cross between French Upright and Alpha (var. *vulgare*) has given an interesting series of variations.

Direction of Variation.—The Cherry tomato is undoubtedly the original tomato, from which have come most or all of the varieties of our garden, with the exception of the currant, which represents a distinct species. One of the first variations from the primitive type is the augmentation of cells in the fruit, followed by a tendency to irregularity in shape. Later, the flowers become monstrous by the production of an abnormal number of parts.

If the Cherry tomato is taken as the starting point of the cultivated tomatoes, the evolution may be expressed as follows :

Cherry	Pear-shaped sorts.—Oblong sorts.
	Orangefield or similar kinds.—Angular sorts.
	Green Gage, Large Yellow, White Apple, etc.—Yellow apple-shaped sorts.
	Little Gem, The Cook's Favorite or similar kinds.—Large red sorts.—Grandifolium. Validum.

There is much direct evidence to support this genesis of the tomato. The most doubtful point is whether the pear tomato has come from the cherry or is aboriginal with it. For a discussion of the reasons for this tabulation drawn from morphology, see an illustrated article in the *American Naturalist*, June, 1887, 573.

An extensive study was made in 1887 to determine the relation of seed production to amelioration. Does seed production decrease as the varieties improve? A study of the results showed, among other important matters, the fact that seed production does not keep pace with increase in weight of fruit, and that seed production bears no constant ratio to degree of devel-

opment of fruit. To illustrate the first point, it is but necessary to cite a comparison of the Red Cherry and Paragon, for while the average Paragon fruit is over twenty-four times heavier than the Red Cherry, its seed production is but two and a half to four times greater. The very wide variations in the average numbers of seeds to a fruit showed that seed production bears no constant ratio to the degree of development of fruit.

Methods of Improvement.—The tomato is quickly susceptible to careful selection. As elsewhere in the vegetable kingdom, the character of the plant as a whole appears to have more hereditary influence than the character of the individual fruit. Large fruits from poor plants or early fruits from habitually late plants, appear to give little if any gain in size or earliness.

The better method of selection is to secure seeds from the most desirable plants.

Direction of Improvement.—The particular points at present in demand in tomatoes are these: regularity in shape, solidity, fair size, productiveness of plant.

The ideal tomato would probably conform closely to the following scale of points: Vigor of plant, 5; earliness, 10; color of fruit, 5; solidity of fruit, 20; shape of fruit, 20; size, 10; flavor, 5; cooking qualities, 5; productiveness, 20.

Solidity of fruit cannot be accurately measured either by weight or keeping qualities.

Cooking qualities appear to be largely individual rather than varietal characteristics.

Keeping qualities are most marked in the small and unimproved kinds. In the large tomatoes these qualities are widely variable within the same variety, and it is evident that they are comparatively undeveloped as a varietal character.

It is questionable if much farther advance in total productiveness is to be gained by producing larger fruits, for the mammoth varieties may give actually less weight of crop than medium sized kinds. Increase in the number of fruits of large varieties is usually associated with decrease of size. The greatest increase in productiveness must come probably from increase in vigor and stature of plant, with corresponding increase in fruitfulness. It is noticeable that the angular sorts which were so largely cultivated a few years ago, are small in stature as compared with our best

sorts. The ratio of productiveness to weight of plant was determined for 172 varieties in 1887. The six best ratios occurred in Island Beauty (resembling Trophy), Hundred Day, King Humbert, Large Red, Yellow Cherry, and Mikado. It will be seen, therefore, that the Cherry tomatoes give as good, or better, ratios of productiveness as the best varieties, and that cultivation has not increased productiveness equally with size of fruit. But if the ratio of productiveness to weight of plant is not increased, increase in size or robustness of plant will give an actual increase of crop per acre, for it is found that the light and spreading plants of Cherry will cover as much ground as the stocky plants of Mikado or Ignotum, which weigh a half more.

Running out.—Varieties of tomatoes run out, or lose their distinguishing characters, and this may take place as well under good culture and selection as under neglect. In other words, the loss of distinguishing characters may result from improvement of the type as well as from deterioration of it. Perhaps ten years may be considered the average profitable life of a variety. Wide variation from the type may occur in varieties of recent introduction, but this may sometimes, no doubt, be attributable to mixing or substitution of seeds.

Double flowers.—A double or monstrous flower upon a young plant is no indication that succeeding flowers upon the same plant will be double, and produce irregular fruits. But varieties which habitually bear double flowers are also the ones which habitually bear irregular fruits.

Hybrids and Crosses.—Hybrids between the Ithaca and Currant were intermediate between the parents in foliage, flowers and fruits. They produce fruit four times larger than the Currant and in clusters of from six to fourteen. It is possible that an important race of tomatoes can be bred from this hybridization.

Crosses between yellow and red varieties have uniformly given red fruits, and crosses between purple and red have given red fruits also. Crosses between the large-leaf tomatoes (var. *grandifolium*) and the common type have given foliage intermediate between the two.

Tomatoes mix spontaneously in the field, and seeds should be selected from those plants which are somewhat removed from other kinds.

II. CULTIVATION IN THE FIELD.

Fertilizing.—Very heavy fertilizing with stable manures or concentrated fertilizers has uniformly increased yield in our experiments, although the common opinion is to the contrary. But in order that fertilizing shall produce early fruits, the food materials must be quickly available. If stable manure is desired, only the most thoroughly disintegrated part should be used. Nitrate of soda is a good tomato fertilizer on soils containing abundance of potash and phosphoric acid, but like other incomplete fertilizers it has little value when used alone on poor soils. Nitrate of soda appears to give heaviest yields when used in two or three applications, but in this latitude it should not be applied later than the first of August, else it prolongs growth too late.

There appears to be differences in varieties as to the readiness with which they respond to fertilizing. In our tests of 1891, unimproved or Cherry tomatoes, while showing a less increase in number of fruits than the large varieties under heavy fertilizing, suffered no loss in size of fruits and consequently gave a greater proportionate crop.

In 1889, tests indicated that poor soil may tend to render fruits more angular.

Starting the Plants, Transplanting, etc.—Frequent transplanting of the young plants and good tillage, are necessary to best results in tomato culture in this latitude.

Plants started under glass about ten weeks before transplanting into field gave fruits from a week to ten days earlier than those started two or three weeks later, while there was a much greater difference when the plants were started six weeks later. Productiveness is greatly increased by the early planting.

Very early setting of stocky plants in the field, even in dark and raw weather, augmented earliness and productiveness in 1890. This year the same results were obtained except that there was some gain in earliness from very early setting. The tomato can endure much more uncongenial weather when set in the field than is commonly supposed. Early setting on well prepared land therefore appears to be advisable.

In 1891 two transplantings gave better results than one or three; but the value of transplantation depends almost entirely

upon the earliness of sowing, the character of the plants and facilities for handling.

Seedling plants are better than cuttings.

Trimming the plants lightly in mid-summer appears to increase yield and earliness. But it should not be performed in this latitude after the first half of August.

Training.—Training to stakes is not desirable unless the plants are pruned. Plants tied to two or three stakes, the vines being wound about them, as often recommended, ripen their fruits unevenly and the labor of picking from the tangled mass of foliage is great.

A platform of boards laid under the plants and supported by blocks four or five inches high and then covered with straw keeps the tomatoes clean and renders picking easy, but it appears to increase the rot.

A cheap and rough rack which gives good results is made of narrow slats laid crosswise the row upon two parallel bents which stand on either side of the row and about three feet apart. These bents run lengthwise the row and are made by nailing a light board to stakes every six or eight feet. The bents or sides stand about a foot high. The plants lop onto the cross slats—which may be laid on loosely—and the fruits ripen uniformly and are usually more exempt from rot than those lying on the ground.

Training to a single stem greatly increases the yield per square foot, gives earlier fruits, and decreases injury from rot. This system is advisable for home use, and in some cases for market plantations.

Hilling the plants twice, as potatoes are hilled, has given no beneficial results.

“Leggy” or badly drawn plants can be made to give fairly good results by setting them deep and burying the larger part of the slender stem. But even then they are inferior to stocky plants.

General Points in Cultivation.—The essential general points in profitable tomato culture are these: Careful selection and breeding; early sowing; frequent or at least occasional transplanting to obtain stocky plants; rich soil, well prepared and well tilled. Cool and dark weather in early fall, and early fall frosts, are the leading drawbacks to profitable tomato culture in the North. To

avoid these dangers as much as possible, plants must be started early and forced rapidly.

Rot.—The tomato rot is due to a fungus (*Macrosporium tomato*). This can be kept in check by spraying with Bordeaux mixture or ammoniacal carbonate of copper, but it is difficult to apply the material to untrained plants, especially if upon rich soil, where they make a thick growth. Plants which are trained to stakes and pruned admit of thorough treatment. The rot appears to be less, as a rule, if the plants are so trained that the fruits and vines dry off quickly after rains and dews. In single-stem training out of doors, rot was greatly reduced this year. Straw placed underneath vines appears to increase the tendency to rot, and the same appears to be true of heavy dressings of stable manure. The less improved varieties of tomatoes, like many of the old angular sorts, and the cherry and plum varieties, are almost exempt from attack.

There is often great difference in the amount of rot occurring upon different varieties grown side by side, but it is not yet determined if this difference is attributable to any predisposition to rot on the part of some kinds and immunity on the part of others. It is probably largely a matter of accident. In some cases the same variety from different sources shows marked differences in amount of rot. For instance, in 1886, Favorite from Henderson showed 20 per cent. of rot, while from Sibley it showed 90 per cent. ; Cardinal from Henderson, 5 per cent., from Sibley 75 per cent., Queen from Henderson, 10 per cent., from Nellis 75 per cent. ; Golden Queen from Rawson, none, from Burpee, 90 per cent.

It is possible that the vigor of the plant may have something to do with attacks of rot.

Varieties.—Nearly 300 varieties have been growing during the last six years, of which about one-tenth possessed decided merits. The larger part of those grown five or six years ago have now disappeared or are little known.

Varieties recommended in 1886: Boston Market, Conqueror, Red Valencia Cluster or Queen, Trophy, Beauty, Paragon. The earliest varieties in 1886 were Advance, Precursor, Boston Market, Tom Thumb, Conquerer and The Cook's Favorite.

In 1887 the sorts recommended as best for market were Acme,

Paragon, Queen, Puritan, Optimus, Red Valencia Cluster, Potato Leaf, Mikado and Yellow Jefferson.

In 1889: The following varieties appeared from the season's work, to be among the best market tomatoes: Ignotum, Beauty, Mikado, Perfection, Favorite, Potato Leaf. The following recent introductions appeared to possess merits for market: Bay State, Atlantic, Brandywine, Jubilee, Matchless, and perhaps Lorillard, Prelude and Salzer. The following recent introductions seemed to be particularly valuable for amateur cultivation: Dwarf Champion, Lorillard, Peach, Prelude.

In 1890, the best market tomatoes appeared to be Ignotum, Favorite, Bay State, Atlantic, and perhaps Ruby among the red varieties; Beauty, Mikado and possibly Potato Leaf among the pink or purple varieties; Golden Queen among the yellow sorts. Among the novelties, Ruby and Chemin Market were most promising.

In 1891, Ignotum was still the best tomato, while the new introductions worthy of special mention were Cumberland Red, Long Keeper, Mitchell, Potomac, Red Mikado and Stone.

These records show how transient is the life of a variety in popular estimation.

The Ignotum and Ithaca tomatoes have been sent out by us and the former has taken high rank.

III. CULTIVATION UNDER GLASS.

The tomato can be forced for winter bearing to advantage, but it demands close and constant attention. A tomato house should be very light, warm, and the roof should be at least five feet above the beds or benches. An abundance of sunlight is essential. The temperature should be about 60° to 65° at night and 70° to 80° during the day, or higher in full sunshine. House tomatoes demand a rich soil and a liberal supply of fertilizers.

In this latitude house tomatoes bear when four to five months old.

Tomatoes like brisk bottom heat. They may be grown in large boxes or upon benches; 18-inch square boxes, placed about a foot apart, and containing four plants to the box, afford one of the neatest and best means of growing tomatoes.

Winter tomatoes must be trained. From one to three stems, depending upon the distance apart of the plants, are allowed to

grow from each plant. These are trained upon perpendicular or ascending cords. The plants must be pruned as fast as new shoots appear. The heaviest clusters should be supported.

Water may be used more freely early in the growth of the plant than later. Wet the soil thoroughly at each watering, rather than water often. When the fruit begins to set keep the atmosphere dry, especially during the middle of the day.

In midwinter the flowers should be pollinated by hand. This may be done by knocking the pollen from the flowers when the atmosphere is dry and catching it in a spoon or other receptacle, into which the stigma is thrust.

One-sidedness and much of the smallness of house tomatoes appears to be due, at least in part, to insufficient pollination.

a. One-sidedness appears to result from a greater development of seeds upon the large side.

b. This development of seeds is apparently due to the application of the pollen to that side.

c. An abundance of pollen applied over the entire stigmatic surface, by increasing the number of seeds increases the size of the fruit.

d. The pollen, either directly or indirectly, probably stimulates the growth of the fruit beyond the mere influence of the number of seeds.

The second crop of fruits is obtained by training out a shoot or shoots from the base of the old plants, by burying the old plant, or by starting a new seedling crop. The first method appears to be the best.

House tomatoes in this latitude yield about 2 lbs. to the square foot. The amount of the first crop does not appear to influence the amount of yield in the second crop from the same plant.

Lorillard, Ignoutum, Volunteer, Ithaca, Golden Queen and Beauty we have found to be good winter tomatoes.

Insect pests are kept in check by fumigating with tobacco, and the spotted mite by Hughes' fir-tree oil. Fungi are controlled by ammoniacal carbonate of copper and Bordeaux mixture.

L. H. BAILEY.

CORNELL UNIVERSITY

Agricultural Experiment Station.

BULLETIN 33.

ENTOMOLOGICAL DIVISION.

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WIREWORMS.

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BULLETINS OF 1891.

26. Experiences with Egg Plants.
27. The Production and Care of Farm Manures.
28. Experiments in the Forcing of Tomatoes.
29. I. Cream Raising by Dilution.
II. The Effects of a Delay in Setting on the Efficiency of Creaming.
- III. Application of Dr. Babcock's Centrifugal Method to the Analysis of Milk, Skim Milk, Butter-milk and Butter.
- IV. The Relation of Fibrin to the Effectual Creaming of Milk.
30. Some Preliminary Studies of the Influence of the Electric Arc Lamp upon Greenhouse Plants.
31. The Forcing of English Cucumbers.
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33. Wireworms.

WIREWORMS.

RESULTS OF EFFORTS TO DISCOVER A PRACTICABLE METHOD OF PREVENTING THE RAVAGES OF THESE PESTS, AND A STUDY OF THE LIFE HISTORY OF SEVERAL COMMON SPECIES.

INTRODUCTION.

AMONG the most prominent of the pests that infest field crops are the insects commonly known as wireworms. These are long slender grubs of a yellowish white color and unusually hard bodies. The wire-like form and the hardness of the body has suggested the common name. Figure 1 represents one of these insects, natural size; Fig. 2, one enlarged.

FIG. 1.—*Lateral view of Wire-worm, natural size.*

Unfortunately the term wire-worm has been misapplied to certain insects which pertain to a different order, the millipedes; and this error has found its way into some entomological publications. It is, therefore, necessary to state in this place that the



FIG. 2.—*Dorsal view of Wire-worm, enlarged two diameters.*



FIG. 3.—*A Millipede.*

The true wireworms are the young of click-beetles, or snapping bugs as they are more commonly termed. Our common species of click-beetles are mostly small or of medium size, ranging from one-tenth to three-fourths inch in length. A few species are larger, some reaching the length of nearly two inches. Figures 4 and 5 represent two common species of these insects. The transformations of several species are described in the following pages.

The click-beetles or snapping-bugs have received their com-



FIG. 4.—*A click-beetle.*

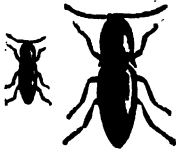


FIG. 5.—A Click-beetle, *Drasterius elegans*, natural size and enlarged.

mon names from the fact that when they are held by one end they will suddenly bend the body, producing a click-like sound; or when placed upon their backs, upon some hard object they will suddenly bend the body, producing a similar sound, and throw themselves a considerable distance in the air. This is their method of regaining their feet when they fall upon their backs; for, like turtles, they are unable to roll over.

The young of click-beetles, the wireworms, live in various situations, each species having its peculiar habits. Many species are not at all injurious to agriculture.

But certain other species live in the soil and feed on the roots of plants, and on seeds. These species are often exceedingly injurious; and as they work in the ground out of sight, it is very difficult to combat them.

For three years we have been making numerous experiments to ascertain a practical method of preventing the ravages of these pests. Unfortunately our efforts have not been attended with that degree of success for which we had hoped. For although we have learned how to trap and destroy the adult insects, and that by fall plowing the pupae and recently matured adults, as well as the larvæ about to change to pupae, can be destroyed, we have been unable to discover any practicable way in which seed can be protected from the ravages of wireworms, or how immature wireworms can be cheaply destroyed in the soil. Instead of this we have succeeded in proving the futility of many methods that have been very generally recommended for the destruction of these pests.

Although the chief object of our investigations, the discovery of a practicable method of preventing the ravages of wireworms, has not been accomplished, it seems worth while to publish the results of our experiments, as they may save farmers from making expensive efforts that will surely bring no adequate returns.

The successful General before entering upon a campaign prepares a plan of operations. He carefully surveys the field hoping to discover weak points in the enemy's defenses that may admit of successful attack; he also looks along his own lines in order to guard against there being insufficiently protected points.

In his warfare against wireworms, the agriculturist has not yet succeeded in making this preliminary survey. He knows very well some of the weak points in his own defenses ; but he has not yet discovered how to strengthen them. Much less has he been able to discover a point at which he can successfully wage an offensive campaign.

Much has been written upon this subject ; and many plans both of offense and defense have been prepared. But these plans have been based upon reasoning, not upon carefully ascertained facts ; and when these plans have been put to a careful test they are found to fail in an unexpected manner. In spite of all that has been written upon the subject we have not found published the results of a single extensive series of carefully conducted experiments. Our writers on this subject have reasoned and written, but have not tested their theories. Thus someone has said that wireworms cannot feed upon buckwheat, and for many years writers have been recommending the starving of wireworms in infested soil by growing buckwheat upon it. Everyone knows how successfully Paris green has been used against many different insects, and it is not strange that we find published a recommendation to coat seed with a paste of flour and Paris green ; the writers urging that the worms will be poisoned in this way and the seed protected. In the following pages we show by the results of carefully conducted experiments that both of these plans of defense are utterly futile.

When we began our experiments three years ago, we confidently expected to be able in a short time to tell farmers how to protect their seed and their growing crops from these pests. We thought that the greatest part of our work would be to determine which of several ways is the most practicable, the easiest used, or involving the least labor or expense. We have done our best ; and we have failed to discover a single satisfactory method of protecting seed, or of destroying immature wireworms in the soil.

We have learned that certain methods of procedure will destroy the larvæ ready to pupate, the pupae and the adult insects ; and we have also learned that many commonly recommended plans are useless. Therefore, as already stated, it seems worth while to publish the results of our experiments in order that other investigators may be spared going over the same ground ; and more es-

pecially that farmers may be saved from continuing practices that involve considerable labor and expense, and that produce no beneficial results.

METHODS OF EXPERIMENTATIONS.

The most important piece of apparatus needed for our studies was a cage in which the wireworms to be experimented upon could be kept as nearly as possible under natural conditions. The cages that were already in use in our insectary were found well adapted to this purpose. The form of cage used most is that shown in Figure 6 and in section in Figure 7. It is made by combining a glass cylinder and a flower pot. The flower pot contains soil in which wheat, clover and grass are growing, in order to furnish food for the wireworms that are kept in the soil. The glass cylinder is firmly cemented in place with plaster of Paris and closed above with a piece of Swiss muslin, which allows free circulation of air.



FIG. 6.—A Breeding-cage.

When these cages are used for ordinary purposes, the glass cylinder is merely set upon the soil. But in our wireworm experiments, as a careful account was kept of the number of wireworms placed in each cage, we wished to be sure that it was impossible for any to escape, hence the cylinders were cemented in place by plaster of Paris. It was also necessary, for the same reason, to plug the hole in the bottom of the flower pot. This rendered it impracticable to wet the soil in the ordinary way. This difficulty was overcome by placing the flower pot inside of a larger one, and filling the intervening space with Sphagnum moss. By keeping the moss wet sufficient water passes through the porous sides of the pot to keep the soil in good condition.

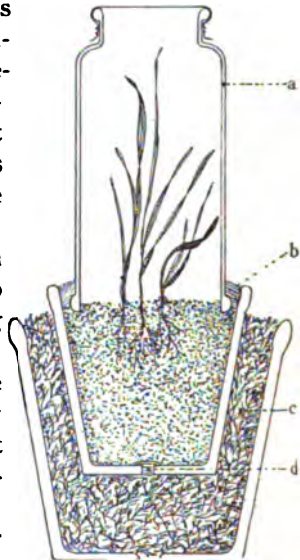


FIG. 7.—A sectional view of a breeding cage.

Figure 7 represents a sectional view of one of these cages. In this

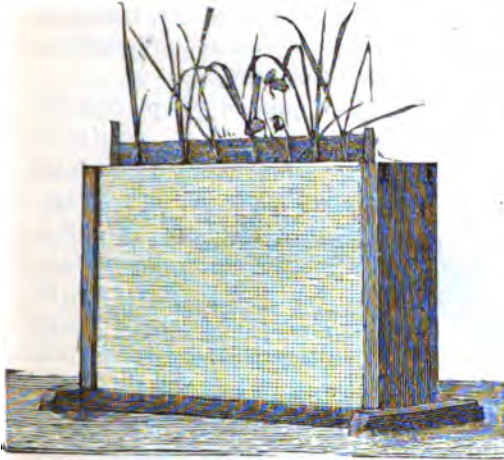


FIG. 8.—*A Root-cage.*

to keep track of their transformations or to determine the effect of our experiments upon them, was to open the cage, by breaking the thin ring of plaster of Paris, and carefully sift the soil in the flower pot. This was done at regular intervals, varying according to the nature of the experiment we were conducting. After each examination the living insects were returned to the pot in which the sifted soil had been placed and resown to seed, and the cage closed as before.

For certain experiments it was necessary to be able to watch the wireworms while they were at work below the surface of the soil. For this purpose we used a modification of the root cage described in Bulletin III. The cage as we now use it is represented in Figures 8 and 9. In Figure 9 the parts shown are as follows: *a*, plate of glass forming back of cage; *b*, space filled with moss;

figure the parts are as follows: *a*, glass cylinder; *b*, plaster of Paris cement; *c*, moss; *d*, plug in flower pot.

As the wireworms work out of sight in the soil the only way in which we were able

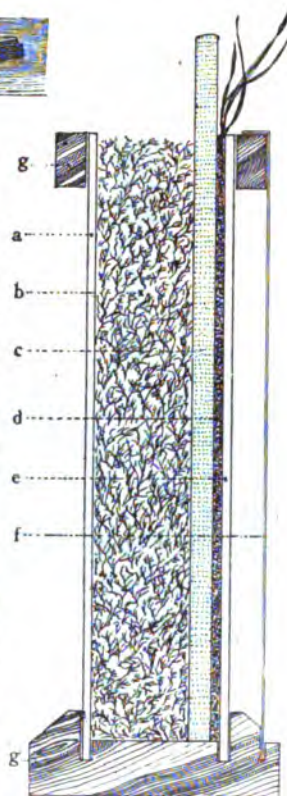


FIG. 9.—*A sectional view of a root cage.*

c, porous tile ; *d*, thin space filled with soil in which seed is sown and the wireworms to be watched are placed ; *e*, plate of glass forming the front of the cage ; *f*, a sheet of zinc for darkening the cage ; *g, g*, sections of wooden frame of cage.

The thickness of the space *d* is regulated by placing a thin strip of wood at each end of the cage between the glass *e* and the porous tile *c*.

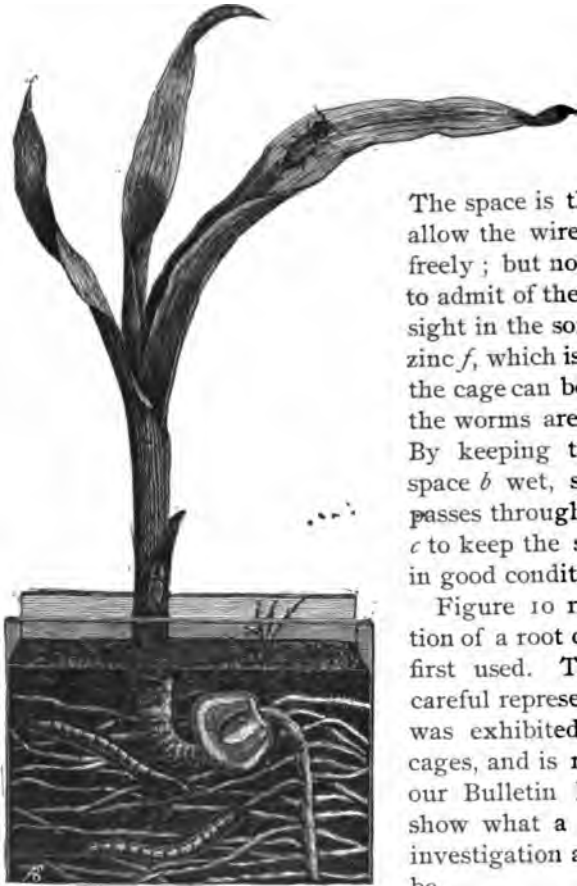
The space is thick enough to allow the wireworms to move freely ; but not thick enough to admit of their getting out of sight in the soil. The sheet of zinc *f*, which is used to darken the cage can be removed when the worms are to be watched. By keeping the moss in the space *b* wet, sufficient water passes through the porous tile *c* to keep the soil in the cage in good condition.

Figure 10 represents a section of a root cage of the form first used. This figure is a careful representation of what was exhibited by one of our cages, and is reproduced from our Bulletin III in order to show what a valuable aid to investigation a root cage may be.

A third form of cage was devised in order to test the efficacy of salt as a repellant.

FIG. 10.—A corn-plant growing in a root-cage infested by wireworms and click-beetles. (From a specimen in the Cornell Insectary).

This is figured and described on a later page, where the experiment is discussed.



DETAILS OF EXPERIMENTS.

In conducting our experiments both defensive and offensive measures were undertaken. Thus we tried to protect seed by coating it with poisons, and by treating it with various substances that we hoped would render it distasteful to the insects; and we tried to destroy the insects in each of the three stages of their existence, larva, pupa, and adult. Experiments in the destruction of the eggs were not undertaken for lack of opportunity. The following table indicates the scope of our experiments, and the order in which they are discussed in the following pages:

A. Protection of Seed.

1. By a Coating of Paris Green and Flour.
2. By a Coating of Tar.
3. By Soaking in a Salt Solution.
4. By Soaking in a Copperas Solution.
5. By Soaking in a Chloride of Lime and Copperas Solution.
6. By Soaking in Kerosene Oil.
7. By Soaking in Turpentine.
8. By Soaking in a Strychnine Solution.

B. Destruction of Larvæ. (Wireworms).

1. By Starvation.

(a). Clean ~~Tallow~~ *Fallow*

(b). Growth of Supposed Immune Crops.

Buckwheat.

Mustard.

Rape.

2. By the use of Insecticides.

(a). Substances that act merely as Insecticides.

Kerosene Oil, Pure and as an Emulsion.

Crude Petroleum, Pure and as an Emulsion.

Poisoned Dough.

Bisulphide of Carbon.

(b). Substances that act also as Fertilizers.

Salt.

Kainit.

Muriate of Potash.

Lime.

Chloride of Lime.

Gas Lime.

C. Destruction of Pupæ and adults (Click-beetles).

1. By Fall Plowing.
2. By Trapping.

A. PROTECTION OF SEEDS.

The most conspicuous of the injuries caused by wireworms is the destruction of seed immediately after it is planted, and before there has been time for it to germinate. Although these insects may do great harm later in the season by destroying part of the roots of the growing plants, such injuries are not so keenly appreciated by the farmer as the destruction of the seed. For this reason more attention has been given by farmers to efforts to protect seeds from wireworms, than to any other method of combatting these pests.

The most obvious way of protecting seeds is to coat it with some substance which will render it distasteful to the insects or with a poisonous substance which will destroy the insects if they attempt to eat the seed. Several substances have been recommended for this purpose. And in the case of some of them the recommendation has been repeated so often that there appears to be no doubt concerning their efficiency. But as we could find no evidence that these recommendations were based on carefully ascertained facts we determined to test each of them. The following gives the results of our experiments in detail:

I. PROTECTION OF SEED BY A COATING OF PARIS GREEN AND FLOUR.

This method suggested by Professor Fernald* promised to be the most desirable one. For, if it resulted as we confidently expected it would, not only would the seed be protected but the poisoning of the wireworm would effectually guard against any farther injuries by them. For this reason it was the first of the proposed methods of protection tested by us.

Five root cages were made as described on pages, 196-8, and ten wireworms were allowed to bury themselves in the soil in each cage; then five or six kernels of corn were given a good coating of a mixture of one part of Paris Green to twenty parts of flour, and planted in the narrow space in each cage. The cages were

*Annual Report Massachusetts(Hatch)Experiment Station, January, 1889, p. 9.

examined every day for fifteen days ; and there was no day after the first but what some larvæ could be seen in nearly every cage eating the corn. On the fourth day at one time five wireworms were at work on one kernel, and quite frequently three or four were seen eating a single kernel. The kernels in two cages were taken out and examined on the tenth day. All had been attacked and most of them destroyed before germination began. Fresh kernels coated with a mixture containing twice the amount of Paris Green as at first were then planted in the same cages. The wireworms soon attacked these kernels also, and when all the cages were broken up we failed to find any indications that the larvæ had been affected by the poison, although nearly every kernel had been destroyed by them. If a kernel sprouted, the larvæ were seen to attack the root or the sprout and kill it.

In the following spring, 1890, we made other experiments using the form of cages shown in figure 6. Five kernels of corn were wet and coated with a mixture of one part of Paris green to twenty parts flour, and planted in a cage with twenty-five wireworms. The cage was examined at intervals of two weeks until September, and freshly coated kernels planted. The kernels had sprouted each time and rarely showed any attack by the larvæ.

Although we succeeded in growing the corn in this experiment, it was not because the Paris green in the coating destroyed the larvæ, but because the wireworms did not attack the kernels. It is true that there was a gradual decrease in the number of live larvæ found in the cage at each examination, but this was due to natural causes ; some had been killed by a fungus disease and others had pupated.

In October, having received a fresh lot of wireworms, this cage was again started. Six kernels of corn were coated as before, planted in the cage, and forty larvæ were placed just beneath the surface, thus making sure that some of them would find the kernels as they burrowed downward. To eliminate possible sources of error and to more fully test the accuracy and practical value of this experiment, a comparative or check experiment was started. The two cages used in this check experiment were similar to the cage in the original experiment in the number of kernels planted and the number of larvæ put in each cage, but kernels in the check cage were not coated. All of the cages were

kept under the same conditions and examined at intervals of about two weeks. At the first examination, four of the kernels in the experiment cage and five in the check cages had been destroyed before germination began. There was also an indication that the germination of the coated kernels, which had not been attacked, was retarded. All of the wireworms were found alive.

The cages were again started under the same conditions as before, and were examined Nov. 21st. The germination of the seeds in the experiment cage had been greatly retarded. But this was the only result observed; none of the kernels had been attacked, and all of the larvæ were alive. It was found, however, by other experiments that these wireworms eat but little, if at all, during the autumn months; hence the exemption from attack of the corn proved nothing regarding the protective measure employed.

In April, 1891, wireworms which had been kept in hibernating cages during the winter, were taken and the experiment and check cages again started. The examination two weeks later showed that nearly all of the kernels in the check cages and four of them in the experiment cage had been destroyed. All of the larvæ were found alive, and further experimentation in this line seemed useless.

It was thought probable that if the poisoned paste was sweetened, the wireworms might eat it more readily. Kernels of corn were coated with a paste made of ten parts each of water, sugar, and one part of Paris Green, and planted in a cage with twenty-five larvæ. The cage was examined and started afresh at frequent intervals for three months, but none of the kernels were attacked and all failed to germinate even when soaked in water before coating.

From this series of experiments extending over a period of nearly two years, it was evident that it is not practicable to protect seed from the attacks of wireworms by coating it with a paste containing Paris green. The only apparent result of such coating was to retard the sprouting of the seeds. When wireworms did eat seed thus coated they did not appear to be injuriously affected by the poison.

This remarkable result is not entirely unprecedented. The action of the arsenites on the common Rose-bug (*Macrodactylus*

subspinosus^{os}) is so slow that many observers claim that this insect can eat with impunity foliage that has been sprayed with these poisons.*

2. PROTECTION OF SEED BY A COATING OF TAR.

It has long been a common practice among farmers all over the country to coat their seed corn with tar to prevent its being attacked by wireworms. And yet it has never been experimentally demonstrated that wireworms will not attack corn thus coated.

August 13, 1890, we began experiments to test the efficacy of this preventive measure. Twenty wireworms were placed in a cage in which six kernels of corn had been planted. The kernels were soaked in water for sixteen hours and then given a good coat of tar, after which they were rolled in ashes to facilitate handling. On September 6, only one kernel had sprouted; the others had rotted. Ten live and eight fungus-killed larvæ were found.

A few hills of corn planted in a bed as a check experiment showed that the tar coating retarded the germination of the seed, and especially so when, after being coated and rolled in ashes, the kernels were allowed to dry as would be necessary if they were to be used in a planter.

As we had no more larvæ in stock, the cage was broken up until a fresh lot was received, October 20, 1890. Then both an experiment and a check cage were started. In the check cage, the kernels were untreated, while those in the experiment cage were prepared in the same manner as before. Forty wireworms were placed just beneath the surface in each cage. November 3, all of the kernels in the experiment cage were growing and had not been attacked. In the check cage, four kernels had been destroyed before and one just after germination. The larvæ were

*We did not know at the time of our experiments with Paris green that Prof. Forbes had inferred, from a few experiments he had made to June, 1885, the doubtful efficiency of Paris green to protect seed corn. He treated sprouting corn with water containing suspended Paris green, and he mixed Paris green in the soil in which the corn was planted. In the latter case the corn failed to grow, and in neither case was it attacked nor were the larvæ injured by the presence of the arsenite in the soil. (Miscellaneous Essays on Economic Entomology, p. 182 in Trans. Illinois State Board of Agr. for 1885.)

all found alive. This result indicated that the coating was a protection. The larvæ were replaced in the same cages which were planted with corn treated in the same manner as before. November 21, none of the kernels in either cage had been attacked by the larvæ which were all alive.

The cages were again started in the same manner as before except that only about two inches of soil was placed in the pots, and the kernels in both cages were soaked for twenty hours in water. December 8, all the kernels were growing and none had been attacked.

The last two results indicated that the larvæ had ceased eating and were in hibernation as the untreated kernels in the check cages were undisturbed. The cages were therefore broken up until spring.

May 26, 1891, they were again started. All the kernels were soaked in water twenty-two hours and those in the experiment cage were given a thick coat of tar. Forty fresh larvæ were allowed to busy themselves in each cage. June 30, the cages were examined, and all the kernels in the experiment cage had failed to germinate except one which had a small root that had been destroyed by the larvæ. In the check cage, every kernel had been destroyed before germination. Thirty-one live larvæ were found in each cage.

Thus far, the results of our experiments seemed to indicate that the tar coating was a preventive, but it was thought best to make one more test. Therefore, July 7, one check and two experiment cages were started. In experiment cage 1, the six kernels were soaked in water for twenty hours, then coated and rolled in ashes. Especial pains were taken to completely coat the kernels. The kernels in experiment cage 2, were treated the same as those in cage 1, except that only about two-thirds of the kernel was coated. The kernels in the check cage were soaked but not coated. One hundred fresh larvæ, nearly full grown, were placed in each cage.

The cages were examined July 20. In experiment cage 1, but two kernels had begun to germinate and in one of these a larva had buried itself. In another kernel a larva was found completely buried, it having entered through a small hole at the point of the kernel. Two other kernels also showed signs of having been

attacked. In experiment cage 2, two sprouts were growing and every kernel but one had germinated. But larvæ were found boring into nearly every kernel where the germ had burst through. Every kernel in the check cage had been destroyed either before or just after germination.

These results are very different from those before recorded ; and they show that sometimes larvæ will attack seed corn even when it is completely coated with tar. In actual practice, but few of the kernels would get a complete coat ; it requires considerable disagreeable labor to apply the coating ; germination is considerably retarded, even when the kernel has been previously soaked in water ; and corn thus treated cannot be readily used in a planter. From these considerations it can be seen that this method of protection does not afford that degree of certainty and practicability which is desired.

3. PROTECTION OF SEED BY SOAKING IT IN A SOLUTION OF SALT.

The soaking of seed corn in salt brine before planting to prevent its being eaten by wireworms was a common practice many years ago among farmers in the western portion of this State. Our experimental tests of the efficacy of this method were begun in July, 1890. Five kernels were soaked in a saturated salt solution for ten hours and then planted in a cage (Fig. 6) with twenty wireworms. At the first examination July 23, three kernels had sprouted and the other two had been attacked by the larvæ. Then five kernels which had been soaked for twenty-four hours in the solution were planted in the same cage. August 5, two kernels had sprouted, one had been eaten, and the others were rotten. The number of live larvæ had been reduced to ten by pupation and a fungus disease.

The cage was not started again until October 20, when a fresh lot of wireworms was received. Forty of these were placed just beneath the surface in a cage in which was planted six kernels of corn which had been soaked in brine eighteen hours. A check cage containing forty larvæ and six unsoaked kernels was also started. November 3, the cages were examined and the same result obtained from both ; in each four kernels had been destroyed before germination, one just after germination, and one was growing nicely. No dead larvæ were found.

After soaking six kernels for twenty hours in the brine, the cages were again started with forty larvæ. When examined November 22, none of the kernels had been attacked in either the experiment or check cage. To more fully determine whether this result was due to the wireworms having begun to hibernate, the cages were again started with forty fresh larvæ and only two inches of soil was placed in the pots. On December 8 none of the kernels had been attacked and all were growing.

April 27, 1891, six kernels were soaked for twenty hours in the salt solution and planted in the experiment cage. The check cage was also started with six unsoaked kernels. Forty larvæ which had been kept in hibernating cages during the winter were placed on the surface of the soil in each cage. Two weeks later the cages were examined and nearly every kernel had been destroyed before germination and all the larvæ were alive.

This series of experiments extending over a period of nearly a year make it evident that sweet corn soaked in a saturated salt solution is as readily eaten by wireworms as if not thus soaked, and no injury results to the wireworms.

4. PROTECTION OF SEED BY SOAKING IT IN A COPPERAS SOLUTION.

In 1876 an Illinois farmer reported favorable results from soaking his seed corn before planting in a solution of copperas (sulphate of iron), to protect it from the attacks of wireworms. In October, 1890, we began experiments to test the efficacy of this substance. Six kernels of corn were soaked for sixteen hours in a solution made by dissolving 15 grains of copperas in one-half pint of water. This seed was planted in a cage containing forty wireworms. A check cage containing six unsoaked kernels and forty wireworms was also started. An examination made November 3d showed that every kernel in both cages had been destroyed before germination began, and all the larvæ were alive.

After soaking six kernels for twenty hours in a solution of 15 grains of copperas to one-fourth of a pint of water, the experiment and check cages were again started with forty larvæ in each. Two weeks later the cages were examined and none of the kernels had been attacked, and the corn was from four to six inches high. This result was due to the fact that the larvæ had been hibernating; for even when the cages were again started

with forty fresh larvæ in each and only two inches of soil in the pots, an examination made December 8 showed that no kernel had been attacked in either the experiment or check cage.

The cages were not started again until April 27, 1891, when six kernels were soaked for twenty hours in a solution of fifteen grains of copperas to one-eighth of a pint of water, and planted in the experiment cage. Six unsoaked kernels were planted in the check cage and forty fresh larvæ were placed on the surface of the soil in each cage. By May 15 the majority of the kernels in both cages had been destroyed and the larvæ were uninjured.

Thus, after two seasons of experimentation with the copperas solution, we have no results which indicate that wireworms will not eat and destroy seed soaked in this solution as readily as any other, and receive no injury therefrom.

5. PROTECTION OF SEED BY SOAKING IT IN A CHLORIDE OF LIME AND COPPERAS SOLUTION.

There has been considerable discussion among farmers as regards the efficacy of soaking seed corn in a solution of chloride of lime and copperas to prevent its being attacked by wireworms. However, no careful experiment had been recorded and so in October, 1890, we started experiment and check cages (see Fig. 6) to thoroughly test the solution.

A [solution containing thirty grains of chloride of lime, fifteen grains of copperas, and one-half pint of water was made and six kernels were soaked in it for eighteen hours before planting. In the] check cage six unsoaked kernels were planted, and forty wireworms were placed just beneath the surface in each cage. November 3, it was found that every kernel in the experiment cage and all but one in the check cage, had been killed before germination began. None of the larvæ were injured.

The cages were again started under the same conditions as before except that the kernels in the experiment cage were soaked for twenty hours in a solution containing only one-half as much water. November 22, an examination of the cages was made and none of the kernels had been attacked except one in the experiment cage. This result indicated that the larvæ had nearly ceased feeding when the cages were started. This fact was made more evident when the cages were again started under the same

(2)

conditions but with fresh larvæ, and on December 8 it was found that all of the kernels were uninjured.

No further experiments were made until April 27, 1891, when six kernels were soaked for twenty hours in a solution containing the same amounts of chloride of lime and copperas as before, but only one-eighth of a pint of water. Forty larvæ fresh from the hibernating cages were placed on the surface of the soil and allowed to busy themselves in both the experiment and check cages. By May 15, every kernel in both cages had been killed before germination began, and none of the wireworms were injured.

After such conclusive evidence it seems hardly necessary to say that a solution of chloride of lime and copperas will not protect seed corn which has been soaked in it from the attacks of wireworms.

6. PROTECTION OF SEED BY SOAKING IT IN KEROSENE OIL.

In October, 1890, we began experiments to ascertain whether wireworms would attack seed corn which had been soaked in kerosene oil. Both experiment and check cages (Fig. 6) were started. Six kernels which had been soaked for fourteen hours in kerosene were planted in the former cage, and six unsoaked kernels in the latter cage. Forty wireworms were placed just beneath the surface in each cage. By November 3, every kernel in the experiment cage had sprouted and none had been eaten; while those in the check cage had nearly all been destroyed before germination. This result indicated that the kerosene effectually protected the seed from attack.

The cages were again started November 5, under the same conditions as before, and at the examination, November 21, all the kernels were uninjured and growing well. Another trial was made November 24 under the same conditions, except that fresh larvæ were used and only two inches of soil were put in each pot. December 8, none of the kernels had been eaten, and the experiment was stopped until spring. The results of the last two trials were no doubt due to the fact that the wireworms had begun to hibernate as had been shown in all of our experiments carried on at this time.

The experiment promised so well in the fall that as soon as the larvæ commenced feeding in the hibernating cages in the spring the experiment was again opened. Forty fresh larvæ were taken for each cage, and the kernels in the experiment cage were soaked for sixteen hours in the kerosene. In the experiment cage, by May 15, only three kernels had sprouted, every kernel had been attacked, and one larva was seen at work on a kernel. In the check cage, four kernels had been killed before germination and two were growing, but one of these contained a larva at work.

At the next trial, May 26, six kernels were soaked for fourteen hours in kerosene and fresh larvæ were allowed to busy themselves in both the experiment and check cages. A month later every kernel in both cages had been killed before germination, and there was no indication that the larvæ had been injured.

The last two results are directly contrary to the result obtained in the fall, but, having been made during the corn planting season, they should have more weight than a single test made just before the hibernating period of the larvæ. Therefore we cannot recommend that seed corn be soaked in kerosene oil to protect it from the ravages of wireworms.

7. PROTECTION OF SEED BY SOAKING IT IN SPIRITS OF TURPENTINE.

The soaking of seed corn in turpentine has been frequently recommended as a preventive against attack from wireworms.

To thoroughly test this preventive, experiments were begun November 5, 1890. Six kernels of corn which had been soaked for fourteen hours in turpentine were planted in the experiment cage (Fig. 6) and forty larvæ were allowed to bury themselves in the soil. A check cage with six unsoaked kernels and the same number of larvæ was started at the same time. Two weeks later all the kernels had sprouted and none had been eaten.

The cages were again started November 24 under the same conditions except that fresh larvæ were taken and only two inches of soil put in the pots. On December 8 all the kernels were found uninjured.

As these two trials were made about the time that the wireworms began to hibernate, the results could not be considered decisive. Therefore, when spring opened the cages were again

started. The six kernels planted in the experiment cage were first soaked for sixteen hours in the turpentine, and forty larvæ fresh from the hibernating cages were allowed to bury themselves in both the experiment and check cages. When the cages were examined May 15, it was found that every kernel had been destroyed before germination began, and there were no indications that the larvæ had been affected.

The experiment was carried no further for this last result was conclusive evidence that wireworms were not deterred from eating seed corn which had been soaked in spirits of turpentine, nor injured by doing so.

8. PROTECTION OF SEED BY SOAKING IT IN A STRYCHNINE SOLUTION.

The idea of soaking seed corn in a solution of strychnine was suggested by the fact that seed thus soaked is used to poison sparrows and gophers. Our experiments to test the efficiency of this substance were begun in August, 1890 with cages like those shown in figure 6. But as we had only a few wireworms then in stock, our results were meagre and indecisive until October, when we received a fresh lot of larvæ. At this time both experiment and check cages were started. Six kernels were soaked for eighteen hours in a solution of one part by weight of sulphate of strychnine to four hundred parts of water and planted in the experiment cage. Forty fresh larvæ were placed just beneath the surface of the soil in each cage. On November 3, the same result was obtained in both cages; four kernels had been destroyed before germination, one just after germination, and one had not been attacked. There were no indications that the wireworms had been injured. Two more trials were made with fresh larvæ during November and December but no kernels were attacked either time, owing to the fact that the wireworms had ceased eating for that year.

April 27, 1891, the experiment and check cages were again started. The experiment cage contained six kernels which had been soaked for twenty hours in a solution of one part strychnine to two hundred parts of water by weight. Forty larvæ fresh from the hibernating cages were allowed to bury themselves in each cage. In the experiment cage May 15, three kernels had been killed before germination and three were growing, but two of

the latter had been quite badly eaten. A similar result was obtained in the check cage. The larvæ showed no signs of injury.

From these results, it will be seen that although seed corn be soaked in a very strong solution of strychnine, it is rendered neither distasteful nor destructive to wireworms.

B. DESTRUCTION OF THE LARVÆ.

The various methods that have been proposed for the destruction of wireworms fall under two heads: first, destruction by starvation; second, destruction by the use of insecticides. We will discuss these separately.

As in the course of the discussion of the experiments in destroying larvae, frequent reference is made to the finding of "fungus killed larvae," it should be stated here that a certain fungus disease frequently made its appearance in our cages. But the appearance of larvae that have been killed by this disease is so characteristic that in no case could there be any doubt as to whether a larva had perished by it or had been killed by the artificial treatment to which it had been subjected. The body of a larva killed by this fungus becomes filled by the growth of the fungus, and assumes a woody appearance. While the body of a larva that has been poisoned becomes soft and decays.

Some fungus killed larvae were submitted, to Professor Roland Thaxter for examination. He reports that the disease is probably caused by the fungus known as *Metarrhizium anisopliæ*.

1. DESTRUCTION OF WIREWORMS BY STARVATION.

(a) *Starvation by Clean Fallow.*

It has been the general belief that the wireworms which infest our fields could live but a short time in soil in which no vegetation was allowed to grow. No experiments have been recorded, however, to determine how long the worms could live in such soil.

Our experiments in this line began in October, 1890. Both check and experiment cages like those shown in figure 6 were used. October 10, check cage 1 was sown to clover and timothy, and seventeen larvae were placed in it. Three days later a second check cage containing twenty-five larvae, and sown to timothy and

clover, was started. Three experiment cages were started on October 17. The soil in cages 1 and 2 consisted of equal parts of sand and garden loam. In cage 3 the soil consisted of one part sand, two parts loam, and one part leaf mould. Twenty-five larvae were placed in each cage and no seed was sown.

November 28, all the larvae in the experiment cages, except one in cage 2, were found alive. They were replaced in the same soil and cages 1 and 3 were put in the cold room, and cage 2 in the warm room for the winter.

The check cages were not examined until December 2, when all the larvae except two in cage 1 and one in cage 2 were alive. They were replaced in the same cages freshly sown. Both cages were kept in the cold room during the winter.

April 17, 1891, experiment cage 1 contained thirteen live larvae. No vegetation had started. The larvae were placed in the same soil. In cage 2, there were twenty live larvae, and one weed had started in the cage. The weed was destroyed and the larvae were placed in the same soil. Cage 3 contained nine live larvae and no vegetation. The larvae were replaced in the soil.

In check cage 2, there were sixteen live larvae, which were replaced in the same cage freshly sown. Cage 1 was not examined until April 21 and then contained eleven live larvae. These were placed in freshly sown soil.

July 9, nearly nine months after the cages were started, experiment cage 1 contained twelve live larvae and one pupa. One small stalk of grass was growing in the cage. The larvae were placed in the same soil. In cage 2, there were fourteen live larvae and one stalk of growing grass. The larvae were replaced in the cage. Six live larvae and one pupa were found in cage 3 and no vegetation was growing. The larvae were replaced.

Check cage 2, which was full of growing grass, contained four live larvae. The cage was broken up. In check cage 1, which was not examined until August 3, four live larvae were found. These were replaced in the same soil freshly sown to timothy and clover.

The cages were examined again August 13, ten months after they were started. No vegetation was growing in the experiment cages. Experiment cage 1 contained eight live larvae and one pupa. In cage 2 there were twelve live larvae and two adults. Four live larvae were found in cage 3.

The check cage contained four live larvæ on August 3, and was not examined on August 13 with the experiment cages. The larvæ found in the experiment cages were replaced in the same soil where they remain at the time this is written. But the experiment has been carried sufficiently far already to demonstrate the impracticability of starving out the pests. For just as many wireworms now remain alive in cage 3 where no vegetation has been allowed to grow as in the check cage in which grass has been kept growing. In cages 1 and 2 where no more vegetation has grown than naturally would in a "clean fallow," over one half the larvæ are still alive. What the larvæ have found to feed upon, especially in the soil consisting of sand and loam only, we cannot say. Possibly they may have found sustenance enough in the decayed vegetable matter in the soil, especially in cage 3 which contained leaf mould. Many species of wireworms do live on such substances.

From our experiments therefore we would not advise the farmer to lose the use of his land for a season and the labor necessary to keep it free from all vegetation in the hope that he may thus starve out the wireworms.

(b) *Starvation by the Growth of Supposed Immune Crops.*

It is supposed there are certain crops so distasteful to wireworms that when these crops are grown the worms will either perish from hunger or leave the field, and thus the succeeding crops be spared from the ravages of these pests. The crops usually recommended for starving out the wireworms are buckwheat, mustard and rape.

BUCKWHEAT.

In this country more attention has been directed to buckwheat as a supposed immune crop than to any other. As the evidence we have is meagre and contradictory, we began experiments in July, 1889, to test the immunity of buckwheat from the attacks of wireworms.

Two experiment and two check cages (Fig. 6) were started. The former had buckwheat in blossom growing in them, and the latter contained growing timothy and clover. Twenty wireworms were placed in each cage. One month later all the cages were examined with the following result. In experiment cage 1, twelve

live larvæ and two killed by a fungus were found ; experiment cage 2 contained only eight live larvæ, one pupa, and four larvæ killed by a fungus. In check cage 1, nineteen live larvæ and one pupa were found ; cage 2 contained fifteen live larvæ, two pupae and two fungus killed larvæ. The vegetation in all the cages had suffered severely from the attacks of plant-lice, so we could not judge whether the wireworms had injured it or not. The live larvæ and pupae were replaced in the same cages which had been resown, the experiment cages to buckwheat and the check cages to timothy and clover. During the winter, the cages were all kept in the hot house except experiment cage 1, which was kept in the cold room.

March 15, 1890, all the cages were examined. The buckwheat was dead, and cage 1 contained two live larvæ and one stalk of growing grass, while in cage 2 no live larvæ were found. The clover was alive in the check cages, and in cage 1 seven live larvæ were found, but cage 2 contained only two live larvæ.

This experiment was carried no further. Although the results show slight indications that the buckwheat was effective, still some of the wireworms lived in the buckwheat cages for eight months.

Another similar experiment which gave more striking results was carried on at the same time as the one just recorded. Four cages (Fig. 6), two experiment and two check, were started July 11, 1889, with twenty wireworms in each. The experiment cages were sown to buckwheat and the check cages to timothy and clover at the same time that the larvæ were put in. Experiment cage 1 and check cage 2 were kept in the cold house, and the others in the hot house during the winter. None of the cages were disturbed until May 3, 1890. Then the experiment cages contained no living vegetation. In cage 1, two live larvæ were found, and cage 2 contained four live larvæ. In the check cages, clover and timothy were growing. Cage 1 contained no live larvae, and in cage 2 two live larvæ were found. All the live larvae were returned to the same cages freshly sown. Check cage 1 was broken up. Nothing but buckwheat was allowed to grow in the experiment cages, and May 30 all the cages were again examined. In experiment cage 1, both larvae were alive, and cage 2 contained only one live larva. In check cage 2, the larvae had been killed by a fungus disease.

The larvae in the check cages had thus all died, but several still remained in the buckwheat cages. These were placed in cages in which some buckwheat was then growing, and July 10 the cages were examined. Cage 1 contained one live larva and one live pupa, and the larva in cage 2 was found alive. One small stalk of grass was found growing among the buckwheat in each cage. The larvae were returned to the same cages freshly sown to buckwheat. August 7, cage 1 contained one live pupa, and the larva in cage 2 was alive. As we have very seldom been able to rear pupae after they have once been disturbed, we did not start experiment cage 1 again; but the larva from cage 2 was placed in a cage of growing buckwheat. This cage was examined September 6, October 10, and December 2, and the larva found alive and replaced in a cage of fresh buckwheat each time. During the winter the cage was kept in the cold house, and April 21, 1891, the larva was found dead.

This larva had lived in soil in which buckwheat was growing for about eighteen months, and had been disturbed seven times during that time; while no larva remained alive in the check cages after ten months. Two larvae, after living in the buckwheat cages for one year, changed to pupae; while no larvae in the check cages reached the pupal state.

In October, 1890, we received a fresh lot of wireworms and started a third experiment. Twenty-five larvae were placed in each of two experiment cages (Fig. 6) which were sown to buckwheat. A check cage containing twenty-five larvae was sown to clover and timothy. December 2, experiment cages 1 and 2 each contained twenty-three live larvae and two killed by a fungus. In the check cage, twenty-four live larvae and one fungus-killed specimen were found. The live larvae were placed in the same cages freshly sown as before. Experiment cage 1 and the check cage were kept in the cold house, and the other experiment cage in the hot house during the winter. On April 17, 1891, in experiment cage 1, eighteen live larvae were found, while cage 2 contained only two live larvae. The check cage contained sixteen live larvae, and no living vegetation was found in the cages. The cages were resown and the live larvae replaced. When the cages were examined July 9, three stalks of grass were growing among the buckwheat in the experiment cages, and cage 1 contained

eleven live larvae some of which were changing to pupae. In cage 2 no live larvae were found. Four live larvae and three which had been killed by a fungus were found in the check cage. This experiment confirmed the results obtained in the preceding experiment, and the cages were broken up.

In the experiments thus far recorded, our aim has been to determine whether wireworms could live and undergo their transformations, in soil in which nothing but buckwheat was growing, as readily as they could among clover and timothy roots. To determine whether the wireworms would eat the roots of buckwheat, an experiment was begun August 18, 1889, in which cages like those described on pages 197 and 198 were used.

Three experiment and three check cages were started with the soil space just wide enough to allow for the sowing of the seed. Buckwheat was sown in the experiment, and clover and timothy in the check cages. Ten wireworms were placed in each cage, and daily observations were made. September 7, a buckwheat stalk had been cut near the root, and was wilted. In another cage the next day, the main root of one stalk of buckwheat, which had grown close to the glass, had been cut completely off in two places where a burrow of the larvæ passed the root. One larva was seen to bring its mandibles together on a buckwheat root several times in succession, but it soon crowded under the root and passed on. Whether the larva lacerated the root or not, was not determined. No further results were obtained from the cages, which were soon broken up.

Thus by a series of experiments extending over a period of two years, we have shown that wireworms will attack and cut off roots of buckwheat; and that they can live for many months, and undergo the transformations necessary for the continuance of the species, in soil in which only buckwheat is growing. Therefore as wireworms have lived as long and thrived as well in cages of buckwheat as they have in cages of timothy and clover, we cannot regard buckwheat as an immune crop.

MUSTARD.

In Europe, mustard has long been regarded as a crop that clears the soil of wireworms by starving them out. There is no conclusive evidence, however, and no experiments have been recorded

to show that wireworms cannot live as long among mustard roots as among any other.

For the past two years, we have been experimenting to determine the effect of the White, the Chinese, and the Brown varieties of mustard on wireworms. August 19, 1889, we sowed 3 root-cages (Fig. 8) to white mustard and placed ten wireworms in each. Three check cages were made in a similar manner with ten larvæ in each, and sown to timothy and clover. The cages were examined frequently for three months, but no wireworms were seen at work on the roots in either the experiment or check cages. The experiment proved nothing and the cages were broken up.

Our experiments with Chinese mustard were begun July 11, 1889. In two cages (Fig. 6) containing growing Chinese mustard, forty wireworms were placed, twenty in each. Two check cages sown to clover and timothy and containing twenty larvæ each were also started. The experiment cages were examined August 26, and each cage contained thirteen live larvæ. These were replaced in the same cages freshly sown to Chinese mustard. The check cages were not examined at this time; and experiment cage 1 and check cage 1 were kept in the hot house, and the others in the cold room during the winter. May 3, 1890, all the cages were examined. Experiment cage 1 contained two live larvæ but no living vegetation. In cage 2, three live larvæ and one live mustard plant were found. In check cage 1, there were no live larvæ, but several clover plants were growing. Cage 2 contained two live larvæ, and living clover and timothy. The cages were sown again and the live larvæ placed in them. At the examination May 30, each experiment cage contained one live larva, while the larvæ in the check cage had been killed by a fungus. The live larvæ found in the experiment cages were placed in fresh cages of growing Chinese mustard. July 10, both larvæ were found dead, and each cage contained one stalk of grass among the mustard.

This experiment brought out the facts that wireworms could live in our breeding cages, in soil in which nothing but Chinese mustard was growing, for nearly a year; and that they lived longer under the same conditions than those wireworms which were fed on clover and timothy roots.

The experiment with brown mustard was begun July 11, 1889, by placing twenty wireworms in each of four cages (Fig. 6), two of which contained growing brown mustard and the others growing timothy and clover. In August, the vegetation in all the cages had been nearly destroyed by plant-lice. Experiment cage 1 contained sixteen live larvae, and in cage 2, eleven live larvae were found. In check cage 1, nineteen live larvae and one pupa were found; and cage 2 contained fifteen live larvae, two pupae, and two fungus-killed larvae. The live larvae were replaced in the same cages, freshly sown. As no seeds had sprouted in experiment cage 1, on November 15 it was examined and thirteen live larvae were found and placed in a freshly sown cage. All the cages except experiment cage 2, were kept in the hot house during the winter. The experiment cages were examined April 28, 1890, and no living vegetation found. Cage 1 contained three live larvae and cage 2, four live larvae. These were placed in the same cages freshly sown to brown mustard. March 15, 1890, the check cages were examined and cage 1 contained seven live larvae, while in cage 2 only two were found. Living vegetation was found in both cages. The check cages were no longer continued. On May 30, experiment cage 1 contained one live larva, and cage 2 four live larvae. They were placed in cages of growing brown mustard, and July 10 in cage 1 the larva was alive, while cage 2 contained three live larvae. They were placed in freshly sown cages and August 7, the larva in cage 1 showed signs of changing to a pupa. In cage 2, two of the larvae were alive, and the other had been killed by a fungus. The larvae were placed in cages of growing brown mustard. September 6 the larvae in cage 2 were alive, but the one in cage 1 had died after living among brown mustard roots for over a year. The larvae from cage 2 were placed in a freshly sown cage, and by October 10 one of them had been destroyed by a fungus. The remaining live one was put in a cage sown to brown mustard and was found alive December 2, 1890, and was placed in another freshly sown cage to pass the winter in the cold house. April 21, 1891, the larva was still alive and after being placed in another cage of brown mustard, it remained alive until July 9, 1891, when the cage was broken up.

This larva had thus lived for two years in cages in which nothing grew but brown mustard, and it had been disturbed eleven

times during that period. Although no larva changed to a pupa while in our mustard cages, still we have never kept wireworms alive so long in cages containing clover and timothy.

Therefore our experiments do not indicate that a crop of mustard will render the soil so free from wireworms that the succeeding crop will escape their ravages.

RAPE.

Another crop, upon which it is said wireworms will not feed, is rape. It is but little grown in America, but is considerably grown in England to provide pasture that will fatten sheep readily.

To test the effects of a crop of rape upon wireworms, we started experiment and check cages (Fig. 6) on July 11, 1889. The experiment cages were sown to large-seeded German rape, and the check cages to clover and timothy. After the crops had come up, twenty wireworms were placed in each cage. In August, experiment cage 1 contained seventeen live larvae, and in cage 2 there were sixteen. Check cage 1 contained nineteen live larvae and one pupa, and in cage 2 fifteen live larvae, two pupae, and two fungus-killed specimens were found. The live larvae and pupae were put in freshly sown cages, and experiment and check cages 1 were kept in the hot house, and the others in the cold house during the winter.

The check cages were examined March 15, 1890. In cage 1 there were seven live larvae and in cage 2, only two. Living clover was found in each cage. These cages were then broken up.

April 28, 1890, experiment cage 1 contained three live larvae, but no living vegetation; and in cage 2, two live larvae were found. These larvae were placed in other cages of rape which were again examined May 30. Cage 1 and 2 each contained two live larvae. These were put in two cages of growing rape. July 10, one larva in each cage had died. The live ones were found among the roots near the surface, and were again put in cages in which rape was growing. The cages were examined August 7 and both larvae were found alive among the roots. They were again placed among growing rape. September 6, 1890, both larvae were dead, one of them from a fungus disease.

The results of this experiment, extending over a period of more than a year, show that wireworms lived as long and thrived as well in our breeding cages on roots of rape as in soil in which

clover and timothy were grown. The favorable results reported from growing a crop of rape have no doubt been due, in a great measure, to the fact that the crop is usually grown and cultivated during the summer months, the period when a large percentage of the wireworms are changing to pupae. This is a critical period with these pests, for whenever they have been disturbed in our breeding cages at this time, the pupae and the larvae which are changing to pupae invariably die soon.

From these facts and from the results of our experiment it would seem that rape can no more be regarded as an immune crop than any other crop cultivated at the same time.

2. DESTRUCTION OF WIREWORMS BY MEANS OF INSECTICIDES.

As the species of wireworms which infest growing crops live during their whole larval life beneath the surface among the roots, it is a more difficult matter to reach them with insecticides than those pests which feed exposed on the plants. A substance must have great penetrating and killing power to be of any value. Most of the substances that have been recommended were first applied merely as fertilizers, but in later years their insecticidal properties also have been much discussed. In our experiments we have used many of these fertilizer insecticides, and also some substances that have no fertilizing properties, but act merely as insecticides.

(a) *Substances that act merely as Insecticides.*

Most of the insecticides which we have used are well known and have been used successfully against other underground insects, but we have no record of their use against wireworms.

KEROSENE, PURE AND AS AN EMULSION.

The use of kerosene oil in our experiments was suggested by the satisfactory results obtained by W. B. Alwood who used it to destroy white grubs in the lawn of the United States Capitol grounds. (See *Insect Life*, Vol. I, p. 48.)* In our experiments

*In June, 1885, Prof. Forbes tested the effects of kerosene emulsion and pure kerosene in a few experiments with individual larvæ. He used about the same proportion of kerosene to the soil as we have, and he obtained similar results. (*Miscellaneous Essays on Economic Entomology*, p. 18, in *Trans. Illinois State Board of Agriculture*, 1885.) We did not know of Prof. Forbes' work when our experiments were made.

we used the form of cage shown in figure 6, and allowed nothing to grow in the soil, which consisted of two parts garden loam, one part sand, and one part leaf mould. The kerosene emulsion prepared according to the Riley-Hubbard formula was first experimented with.

May 28, 1890, $7\frac{1}{2}$ c. c. of a dilution, containing one part of the emulsion to twenty parts of water, was sprayed on the surface of the soil in a cage in which twenty-five wireworms had buried themselves. In this case and in all others which follow where the emulsion or pure oil was applied to the surface, it was made to penetrate the soil by spraying the surface frequently, with a hose.

When the cage was examined June 3, only three larvae were found in it. The plaster of Paris plug in the bottom of the pot had become loosened and had evidently afforded an escape for the wireworms. The three larvae and twenty-two fresh ones were placed in another cage and 10 c. c. of the emulsion diluted as before was sprayed on the surface. On July 10, eighteen live larvae were found in the cage near the bottom. They were placed in fresh soil and the surface was sprayed with 20 c. c. of the emulsion diluted only ten times. July 21, we found fourteen live larvae, five of which were near the surface and changing to pupae, and three fungus-killed larvae. The larvae were placed in a fresh cage and the surface of the soil sprayed with 20 c. c. of the emulsion full strength.

At this date another cage was also started. Twenty wireworms were placed in the soil and some wheat sown on the surface. The cage was allowed to stand a few days before it was sprayed with 20 c. c. of the undiluted emulsion.

August 5, both cages were examined. Cage 1 contained four live larvae, two live pupae, and six fungus-killed larvae. In cage 2 there were eight live larvae, two of which were about to pupate, and eight others that had been killed by a fungus. Nineteen fresh larvae were placed in fresh soil $1\frac{1}{2}$ inches below the surface in cage 1 and 20 c.c. of undiluted emulsion was sprayed on the surface. In cage 2, twenty fresh larvae were allowed to bury themselves, after which 10 c.c. of the emulsion diluted with 10 c.c. of water was sprayed on the surface. August 18, cage 1 contained only four live larvae. Seven had been killed by a fun-

gus and four were dead and soft indicating that they had been killed by the kerosene. The remaining three were not found. In cage 2, one dead larva was found on the surface, three had been killed by a fungus, and thirteen live ones were found at various depths in the cage. The experiments with the emulsion were carried no further.

Although the results showed that the emulsion was effective to some extent when made to thoroughly permeate the soil, it had to be used so strong that its cost would make its use on a large scale impracticable. The amount of kerosene oil necessary to make enough emulsion to spray an acre, if used undiluted and at the same rate as in our cages, would be about one thousand gallons. About one hundred and twenty-five pounds of soap would also be required. And to have much effect, the emulsion must be thoroughly driven into the soil by frequent and copious sprayings with a hose. As the emulsion diluted with eight parts of water is said not to injure grass, it could be profitably applied and no doubt with satisfactory results, if made to thoroughly permeate the soil, in cases where valuable lawns or plants are attacked by the wireworms.

Our experiments with pure kerosene oil were begun November 15, 1890. Two check cages were started with twenty-four larvae in each in soil containing no vegetation. In the experiment cage twenty-five larvae were allowed to bury themselves and 20 c. c. of pure kerosene was then sprayed on the surface. This cage was examined November 28 and all the larvae found alive. They were replaced in the same soil, which still smelled quite strongly of kerosene, and the surface sprayed with 20 c. c. of kerosene. Check cage 2 and the experiment cage were kept in the hot house, and check cage 1 in the cold house during the winter.

April 15, 1891, all the cages were examined. In the experiment cage only one live larva was found. The remains of the others were scattered through the soil. No vegetation had started. Check cage 1 contained ten live larvae near the surface among a few roots of grass growing in the cage. In cage 2, twenty-three live larvae were found at various depths, and a few stalks of grass were growing in the cage.

This result indicates that the kerosene was very effective, but the soil was thoroughly permeated as it had been disturbed once after the first application and the same larvae had been replaced; and the same soil again sprayed with an equal amount of kerosene and kept fallow for five months without being disturbed.

A fresh experiment cage was started and twenty-five fresh larvae were placed about one inch beneath the surface, after which it was sprayed with 20 c.c. of kerosene. Fifteen fresh larvae, with the ten taken from check cage 1, were put in a fresh check cage and twenty-five fresh ones in fresh soil in check cage 2. May 25, twenty-three live larvae were found at various depths in the soil in the experiment cage. In check cages 1 and 2 every larva was found alive.

From the results of these experiments with pure kerosene oil, we see that it must be applied in very large quantities, sufficient to kill most vegetation, to be destructive to the wireworms.

The kerosene emulsion is more effective as it is readily miscible with water, and can be made to permeate the soil more thoroughly and to a greater depth without as much danger of injury to vegetation. But neither the emulsion nor the pure kerosene can be profitably applied on a large scale to destroy wireworms.

CRUDE PETROLEUM, PURE AND AS AN EMULSION.

As crude petroleum contains all the essential properties of kerosene, we thought it might prove equally effective against wireworms, and its cheapness would make it more practicable. An emulsion containing one pint of crude petroleum, one half pint of water, and one ounce of whale-oil soap was first used. It was not a very stable emulsion and could not be readily diluted with more than four or five parts of water.

The experiment cage (Fig. 6) was started August 18, 1890, by placing thirteen wireworms two inches below the surface of the soil and spraying 20 c.c. of the emulsion on the surface. The cage was sprayed frequently with the hose. September 5, nine live and four fungus-killed larvae were found. The live larvae were placed in fresh soil and the surface was sprayed with 20 c.c. of the emulsion. The soil was also sprayed frequently with the hose until September 29, when six live larvae were found in the cage. The experiment was stopped until we received more wireworms in October, 1890.

Then two experiment and two check cages were started. Twenty-five larvae were placed in each cage, and the surface of the soil in the experiment cages was sprayed with 25 c.c. of the undiluted emulsion. November 3, each check cage contained twenty-four live larvae near the bottom of the pot. The experiment cages were examined November 7, and all of the larvae were found alive near the bottom of the cages. The larvae were placed in fresh soil, which, in the experiment cages, was sprinkled with 25 c.c. of the emulsion and thoroughly mixed before it was put in the pots. November 26, the larvae in the experiment cages were all found alive at various depths in the soil which was cold and wet from having been kept in the cold house. The same larvae were placed just beneath the surface in fresh soil on which 50 c.c. of the emulsion was sprayed. Cage 1 was kept in the cold house, and cage 2, in the warm room during the winter. The check cages were not disturbed until April 14, 1891, when cage 1, which had been kept in the cold house, contained ten live larvae and a few stalks of growing grass. As the side of the pot was broken, some of the larvae may have escaped. In check cage 2, which had been kept in the warm room, there were twenty-three live larvae and several stalks of grass. The ten larvae from cage 1 were placed with fifteen fresh ones in fresh soil, and eighteen fresh larvae were put with seven from cage 2 in fresh soil. April 17, 1891, the experiment cages were examined. Cage 1 contained only eight live larvae. Remains of the others were scattered through the soil. In cage 2, there were only nine live larvae.

This result indicated that the emulsion had some effect, but it was used in large quantities and remained in the soil for nearly five months. No further experiments were made with the emulsion, as the results did not indicate that it could be made profitable and practicable.

Our experiments with the pure crude petroleum were begun November 15, 1890. Twenty-five wireworms were allowed to bury themselves in the soil in a cage (Fig. 6), after which the surface was sprayed with 20 c.c. of the crude petroleum. November 28, every larva was found alive near the bottom of the pot. They were replaced in the same soil which was again sprayed with 25 c.c. of the crude petroleum. The cage was kept in the cold house during the winter, and on April 17, 1891, it contained only

eight live larvae. This is a similar result to that obtained with the emulsion at this time.

Two cages with twenty-five fresh larvae each, in fresh soil, were now started; 20 c.c. of crude petroleum had been thoroughly mixed with the soil before it was put in the cages. May 25, twenty live larvae were found in each cage.

On the whole the results with the crude petroleum emulsion and those with the crude petroleum are not as promising as those obtained with the kerosene oil emulsion. This may be due in part to the fact that the crude petroleum emulsion is not so readily miscible with water and thus could not be made to permeate the soil as thoroughly when sprayed with the hose.

POISONED DOUGH.

In our experiments in 1888, poisoned sweetened dough was used with some success to attract and destroy the click-beetles. (See Bulletin No. 3, Nov., 1888, p. 38.) As the wireworms in our breeding cages readily came to the surface to eat wheat scattered thereon, it was thought that many might be attracted by sweetened dough placed on the surface.

May 30, 1890, twenty-five larvae were placed on the surface of the soil in a cage (Fig. 6), and after they had buried themselves, a piece of sweetened dough which had been poisoned with arsenic was placed on the surface. June 3, there were no indications that the larvae had eaten the dough, and no larvae were seen within one half an inch of the surface. Fresh poisoned dough was put in the cage. July 10, the cage contained thirteen live larvae and twelve pupae, and the dough had not been eaten. The cage was broken up as it was evident that the wireworms could not be attracted and destroyed by baits of poisoned sweetened dough.

BISULPHIDE OF CARBON.

This substance has been quite extensively used against subterranean insects, as in the case of ants and the root-form of the grape phylloxera. A hole is usually made with a rod in the ground and a small amount of the liquid poured in and the hole immediately stopped up. The liquid readily volatilizes and its deadly gas permeates the soil for a considerable distance. The explosive power of the substance renders it necessary that no fire

should be brought near it. The cost of the liquid and of its application would prevent its being used very extensively, but in certain cases it would be practicable. Therefore we began experiments November 15, 1890, to determine its effect upon wireworms. Twenty-five larvae were allowed to bury themselves in a cage (Fig. 6). Then a small hole was made in the soil and 5 c. c. of the bisulphide of carbon was poured in and the hole quickly stopped. Six days afterwards, all the larvae were dead. They were of the usual color, but had become considerably elongated and slightly swollen.

Twenty-five fresh larvæ were next placed in fresh soil in the same cage, and 1 c.c. of the liquid was poured into the hole. December 6, all the larvæ were found alive and placed in fresh soil in the same cage. Three c.c. of the bisulphide was used this time, and the cage was not disturbed until April 17, 1891, when every larva was found dead.

These results show that the bisulphide of carbon was effective when from 3 to 5 c.c. was used. At this rate it would require about 150 gallons or more than 1000 pounds of the liquid to treat an acre. Therefore, against wireworms its use will be practicable and profitable only on limited valuable areas where choice plants are attacked.

(b) *Substances that act also as Fertilizers.*

There are several substances now in common use as fertilizers which possess some insecticidal properties. Dealers in the potash fertilizers, especially kainit and muriate of potash, claim that the ravages of wireworms are effectually checked by the use of their fertilizers. During the past two years we have carried on a large series of experiments at the Insectary with salt, kainit, muriate of potash, lime, chloride of lime, and gas lime, to determine whether they may be effectually used against wireworms.

SALT.

The stimulating effects of salt on crops have long been recognized by farmers, and many assert that it either destroys the wireworms, drives them deeper into the soil beyond the roots, or renders the soil so obnoxious that the worms leave. The evidence from practical experience is, however, contradictory, and no exten-

sive experiments to learn its effects on the larvae have been recorded.* Our experiments were of two kinds as follows :

1. *Will Salt Kill Wireworms?* Our experiments with salt began May 23, 1890. Four cages like those shown in figure 6 were started. The soil in each cage was four inches deep and weighed when dry about 1.75 kilogrammes ($3\frac{7}{8}$ pounds). It was found that 1.5 grams ($\frac{1}{16}$ ounce) of salt applied to the soil in each cage would be at the rate of one thousand pounds to the acre. Cages 1 and 2 were to determine the effects of the salt applied at the rate of one half ton to the acre. In cages 3 and 4, double this amount of salt was used. In cages 1 and 3, the salt was mixed with the soil, 1.5 grams in the former and 3 grams in the latter. The same amounts of salt were applied to the surface of the soil in cages 2 and 4 respectively. Twenty-five wireworms were placed in each cage and then wheat, timothy, and clover were sown. All the cages were watered frequently on the surface to dissolve and wash in the salt.

July 10, the cages were examined. Cage 1 contained twenty live larvae, eight of which showed signs of pupating. No vegetation had grown. The larvae were placed in the same soil freshly sown.

In cage 2, there were twenty-two live larvae and one killed by a fungus. One stalk of wheat was growing. The live larvae, fifteen of which showed signs of pupating, were placed in freshly sown soil on the surface of which 1.5 grams of salt was sprinkled.

Cage 3 contained twelve live larvae and eleven pupae. No vegetation had started. The larvae were placed in the same soil freshly sown.

In cage 4, thirteen live larvae, three fungus killed larvae, and four pupae were found. There was no vegetation in the cage. The live larvae were placed in freshly sown soil and 3 grams of salt was scattered on the surface.

*In Bulletin 22, Division of Entomology, U. S. Dept. of Agriculture, December, 1889, p. 51, F. M. Webster records three experiments with salt against wireworms. Although in one case salt was applied at the rate of 24,500 pounds per acre to the surface of the soil in a pot, none of the larvae were killed. His experiments, however, did not extend over a longer period than two weeks and the number of larvae involved did not exceed three in each case.

On August 5, cage 1 contained fourteen pupae and three larvae. Considerable vegetation was found. Fifteen fresh larvae were put in fresh soil, in which 1.5 grams of salt was mixed, and the cage was sown to clover and timothy.

In cage 2, there were eight live pupae, four live larvae, and two pupae and two larvae killed by a fungus. The cage was broken up as we had no more larvae.

Cage 3 contained nine live larvae and one pupa. Some vegetation was found. Ten larvae were placed in fresh soil which was mixed with 3 grams of salt and sown to timothy and clover.

In cage 4, four live larvae, two pupae, and three larvae and one pupa killed by a fungus were found. There was no vegetation in the cage. The cage was not started again until a fresh lot of larvae were received.

September 6, cages 1 and 3 were examined. In cage 1, there were ten live and three fungus-killed larvae. Considerable vegetation was growing. Cage 3, contained seven live and three fungus-killed larvae, and a few stalks of grass. These cages were now broken up as it was evident that salt applied at the rate of 1000 or even 2000 pounds per acre did not destroy the larvae nor prevent them from changing to pupae.

September 6, 1890, another cage was started to determine the effects of larger amounts of salt on the wireworms. In each case the surface of the soil was watered frequently. Six grams of salt (4000 pounds per acre) was mixed with the soil, and fifteen larvae placed in the cage.

On October 10, there were eleven live larvae and one killed by a fungus in the cage. Placed the live ones with fourteen fresh larvae in fresh soil in which 12 grams of salt (8000 pounds per acre) was mixed. The cage was sown to timothy and clover.

November 3, no vegetation was growing, and eighteen live and six fungus-killed larvae were found. The eighteen live ones were replaced with seven others taken from stock in fresh soil in which 24 grams of salt (16,000 pounds per acre) was mixed.

By November 21 all the larvae were dead. Most of them retained their color and glistening appearance, but were considerably shorter. Twenty-five fresh larvae were placed in fresh soil in which 18 grams of salt (12,000 pounds per acre) was mixed, and six kernels of corn were planted in the cage.

December 6, only one kernel had sprouted, nine larvae were dead and the remaining sixteen were quite sluggish.

These last two results indicate that salt will kill the wireworms, but it has to be used at the rate of from 6 to 8 tons per acre, or over one per cent. of the soil to a depth of four inches must be salt.

December 6, 1890, the experiment was again started with two experiment and two check cages. The experiment cages each contained twenty-five fresh larvae, and the check cages twenty-four each. Twelve grams of salt (8000 pounds per acre) was mixed in the soil of each experiment cage, while the soil in the check cages was untreated. Each cage was watered on the surface frequently. Experiment cage 1 and check cage 2 were kept in the hot house, and the others in the cold house during the winter.

The cages were not disturbed until April 15, 1891. Experiment cage 1 then contained twenty-one live larvae, most of them near the bottom of the cage. In cage 2, there were nineteen live larvae at various depths in the soil. Check cage 1 then contained twenty-two live larvae at various depths in the soil. In cage 2, twenty-three live larvae were found. No vegetation had started in the experiment cages, but a few stalks of grass were growing in the check cages.

These results showed that salt applied at the rate of four tons per acre and allowed to remain in the soil all winter, had but little effect on the wireworms.

The twenty-one live larvae found in experiment cage 1 were placed in fresh soil in which 24 grams of salt (16,000 pounds per acre) had been mixed. Six fresh larvae were placed with the nineteen taken from cage 2 and put one inch beneath the surface of the soil, and a solution of 18 grams of salt (12,000 pounds per acre) in 80 c. c. of water was poured on the surface. The live larvae found in check cage 1 were replaced in the same soil, and seven of those from cage 2 were placed with eighteen fresh ones in fresh soil in cage 2. •

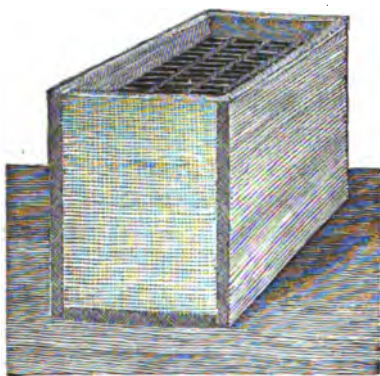
May 15, the experiment cages were examined. Cage 1 contained only three live larvae, which were found near the bottom of the cage. In cage 2, twenty-one live larvae were found near the bottom of the cage.

May 25, check cage 1 contained nineteen live larvæ at various depths in the soil, and in cage 2 every larva was found alive.

From these last results and from those obtained before it will be seen that to destroy wireworms, salt must be used at the rate of about eight tons to the acre, or over one per cent. of the soil to a depth of four inches must be salt. This amount would be very destructive to vegetation. In one of our cages salt applied to the surface at the rate of 1000 pounds per acre prevented one half of the wheat from germinating. When scattered on grass land in July, 4 tons per acre killed all the grass in a few days.

Some crops are able to bear a heavier dressing than others, but from two to eight hundred pounds per acre is the usual amount applied by most farmers to growing crops. The form of salt used as a fertilizer usually costs from \$2 to \$4 per ton in large quantities, and it would be practicable in some instances where valuable land was infested to apply it in sufficient quantities to kill the wireworms. It would be best to apply it at a time when the land could lie in fallow for some time afterward to allow the soil to freshen before the next crop.

2. *Will salt drive wireworms deeper into the soil?*—From practical



experience in the application of salt to growing crops, many farmers have been led to believe that it makes the soil obnoxious to the worms and that they either go deeper into the soil beyond the roots or they migrate to neighboring fields. To ascertain experimental evidence on these points, two cages like the one represented in figures 11 and 12 were devised.

FIG. 11.—*A cage for experiments with salt.*

This cage was in the form of a rectangular box $3\frac{1}{2}$ feet long, 11 inches wide, and 15 inches deep. By means of three longitudinal partitions, and fourteen transverse ones, sixty compartments were made in the box. These compartments began two inches below the top of the box and extended downwards

five inches farther ; below this point the cavity of the box was undivided. The sides of the box were held in place with screws so that they could be removed and the contents of the separate compartments examined. The bottom of the box was largely composed of porous tiles to allow of drainage.

In using these cages they were filled with soil nearly to the top of the compartments. Nine kernels of wheat were planted in each compartment of each cage. Then three nearly full grown wireworms were placed on the surface of the soil in each compartment, and watched till they buried

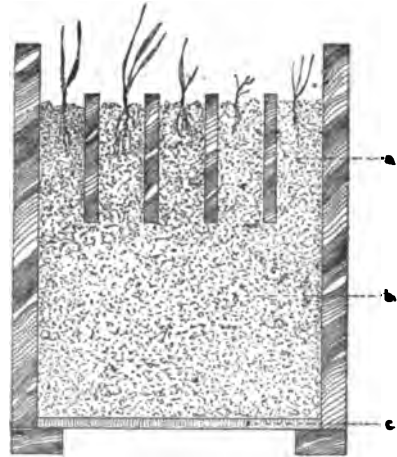


FIG. 12.—Sectional view of cage for experiments with salt. *a*, compartment; *b*, undivided portion of box; *c*, porous tile.

themselves in that compartment. After this was done, salt was sprinkled over one third of each cage (*i. e.* over twenty compartments at one end) at the rate of 1000 pounds per acre. The cages were watered frequently thus washing the salt into the soil.

The idea upon which this experiment was based was that if the salt was obnoxious to the wireworms they would bury themselves deeply, passing down into that part of the box below the compartments, and perhaps even migrate to the unsalted part of the cage.

Seventeen days after the experiment was started, one cage was examined. The results of this examination are given in the following table :

EXPERIMENT WITH SALT. CAGE I.

Number of larvæ found in each half of each compartment of the cage after 17 days. The upper figure in each case indicates the number found less than $2\frac{1}{2}$ inches below the surface ; and the lower figure, the number found between $2\frac{1}{2}$ inches and 5 inches from the surface.

Salted.					Not salted.														
1			1		1	1			3	2			1	1		1			
2				3	3	1		2										2	
1			2	2	1	1	2	1	2	2	2	2						2	
3		1			1	1		2	1	1	2								
		1	1	1		2	1	2	1	2	1						1		
2																			
						1		1	1							1	1	1	2
Totals.					Totals.					Totals.									
8					17					9									
15					16					16									
23 larvæ					33 larvæ					25 larvæ									

From this table it will be seen that seventeen days after the heavy dressing of salt was applied to one third of this cage, nearly as many larvae remained in the compartments of the salted portion as in the compartments of either of the other thirds of the cage. It should be remembered that the compartments were only five inches deep, and that below them the box was undivided, so that there was nothing to prevent the worms from leaving the compartments and migrating to the other part of the box if they found the presence of the salt disagreeable.

The soil in the undivided portion of the box below the compartments was also examined. In that third of this part which was beneath the salted compartments, 17 larvae were found; in the middle third, 13 larvae; and in the third at the unsalted end of the box, 10 larvae.

Taking the experiment as a whole the evidence that there was any movement on the part of the larvæ on account of the presence of the salt is very slight.

Cage 2 was started May 18 and was treated in every respect like cage 1, except that it was left fifty days before examination. On May 25, the wheat in the unsalted compartments was from two to three inches high, while but few stalks had appeared in the salted section. When the examination was made on July 8, it was found that 76 per cent. of the kernels in the unsalted por-

tion had grown, while but 21 per cent. of those in the salted section had sprouted. This shows that the salt had greatly interfered with the germination of the seed ; and had been used, therefore, in greater quantities than would be practicable on fields of grain.

The following table indicates the results of the examination of cage 2. As in the preceding table the number of individuals found in the upper half of each compartment is indicated in the upper half of the space devoted to that compartment in the table ; and the number of specimens found in the lower half of the compartment is indicated in the lower half of this space. While this experiment was in progress the time for full grown larvæ to change to pupæ arrived ; and we found that 46 per cent. of the specimens observed had thus transformed. In the table the number of larvæ and of pupæ found in each half of each compartment is indicated separately.

• EXPERIMENT WITH SALT. CAGE 2.

Number of larvae and pupae found in each half of each compartment after 50 days. The upper two figures in each case indicate the number of specimens found less than $2\frac{1}{2}$ inches below the surface ; the lower two, the number found between $2\frac{1}{2}$ and 5 inches from the surface.

	Salted.					Not salted.									
Larvæ,															
Pupæ.....			I										I		
Larvæ.....		I		2									I		
Pupæ.....		2		I						I				I	
Larvæ.....		I			I		2								
Pupæ.....								2						I	
Larvæ.....	I	I	I	I	3	I		I			I			I	
Pupæ.....		2	I		I	I	2		2					I	
Larvæ.....					I						4	I			I
Pupæ.....						I	I	2	I	2			2		
Larvæ.....	2	I	3	I	I	I	I		I	3	3	3	I	I	
Pupæ.....	I		I				3	I	2	2	2		3	I	
Larvæ.....										I					I
Pupæ.....		I												I	
Larvæ.....	I	I	6		I	4	I	2		I					
Pupæ.....			I		I								2	4	
	Totals. 3 larvæ 2 pupæ					Totals. 3 larvæ 9 pupæ					Totals. 7 larvæ 4 pupæ				
	27 larvæ 11 pupæ					16 larvæ 13 pupæ					11 larvæ 15 pupæ				
	43 specimens.					41 specimens					37 specimens				

One hundred and twenty-one specimens, or 67 per cent. of the whole number of larvæ put in, were found still within the compartments. The others had gone lower into the soil below the compartments, where a few roots had penetrated. It was evident that the larvæ had migrated from one compartment to another to some extent, for several compartments contained more than the number placed in them. One of the unsalted compartments contained nine specimens, and in one of the salted compartments seven specimens were found. Four compartments in each of the three sections contained more than the three specimens put in. In three compartments in the salted section, no specimens were found, while one unsalted section contained seven such compartments, and the other section, eight. In only one case did an un-

salted compartment immediately adjoining the salted section contain more than three specimens, and in a salted compartment beside the unsalted section, four specimens were found. And it will be observed by examining the totals *that more specimens remained in the compartments in the salted section of the cage than in either of the other thirds*. Thus, the slight indication of migration afforded by the examination of cage 1 is more than counter-balanced by this examination of cage 2.

The results of this experiment, therefore, indicate that salt applied at the rate of 1000 pounds per acre (a heavy dressing) interferes with the germination of wheat, and neither drives the wireworms deeper into the soil, nor causes them to migrate any appreciable distance.

KAINIT.

This is a German potash salt which is now much used as a fertilizer in this country. Many English farmers and a few in this country report satisfactory results in destroying or driving away wireworms, when it is applied on badly infested crops.

To experimentally test the effects of this fertilizer, we started a breeding cage (Fig. 6) August 8, 1890. Twenty wireworms were allowed to bury themselves in the soil, after which 1.5 grams (at the rate of 1000 pounds per acre) of kainit was spread on the surface and made to permeate the soil by frequent sprayings with the hose. From 200 to 500 pounds per acre is the usual dressing for most crops.

August 18, the cage contained thirteen live and six fungus-killed larvae, all near the surface. The live larvae were placed in fresh soil in which 1.5 grams (1000 pounds per acre) of kainit was mixed. The surface of the soil was not sprayed, but kept moist by wetting the moss around the pot.

September 6, there were seven live and three fungus-killed larvae in the cage. Ten live larvae were put in the cage in fresh soil and the surface was sprayed with a partial solution of $1\frac{1}{8}$ grams (750 pounds per acre) of kainit in 40 c. c. of water. We have never been able to make a complete solution of the kainit in water, even when the mixture is boiled.

September 29, six live larvae were found in the cage. Fifteen fresh larvae were placed in fresh soil and $1\frac{1}{8}$ grams (750 pounds

per acre) of kainit was scattered on the surface. The surface was sprayed frequently with a hose.

October 10, the cage contained two live larvæ on the surface and eleven more near the bottom of the pot. The thirteen live larvæ were placed with twelve others taken from stock in fresh soil, and 1.5 grams (1000 pounds per acre) of kainit was mixed in the soil. The soil was kept wet by frequent sprayings.

November 3, all the larvæ were found alive but one. This cage was now broken up as other cages had been started to more fully test the kainit.

Thus far there were some indications that the fertilizer was partially effective.

October 17, we received a fresh lot of larvæ, and two experiment and two check cages were started. Twenty-five larvæ were placed in each cage and no vegetation allowed to grow. Each cage was watered frequently with a hose. In the soil of each experiment cage, 1.5 grams (1000 pounds per acre) of kainit was mixed, and the check cages were untreated.

November 3, the check cages each contained twenty-four live larvæ, which were replaced in the same cages. Cage 1 was placed in the cold room and cage 2, in the hot-house for the winter.

All of the larvæ in experiment cage 1, and 24 of those in cage 2 were found alive near the bottom of the pot, November 7. The larvæ were put in the same cages in fresh soil in which 6 grams (4000 pounds per acre) of kainit had been mixed.

November 25, the larvæ in the experiment cages were all found alive and about an inch below the surface. Those from cage 1 were put in fresh soil in which 12 grams (8000 pounds per acre) of kainit was mixed; and 18 grams (12000 pounds per acre) of kainit was mixed in the soil in which the larvæ from cage 2 were placed.

The cages were again examined December 8. Cage 1 contained twenty-four live larvæ. These were placed in fresh soil in which 12 grams (8000 pounds per acre) of kainit had been mixed, and the cage was placed in the cold house.

In cage 2, there were twenty-three live larvæ which were put in fresh soil in which 6 grams (4000 pounds per acre) of kainit was mixed, and the cage was kept in the hot house during the winter.

Both check and experiment cages were examined April 14, 1891. A few stalks of grass had started in the check cages.

Experiment cage 1 contained eighteen live larvae at various depths in the soil. Sixteen of these with nine fresh ones were placed about one inch below the surface in fresh soil, and a partial solution of 12 grams (8,000 pounds per acre) of kainit in 40 c.c. of water was poured on the surface.

In experiment cage 2, there were seventeen live larvae found at various depths. Fourteen fresh larvae and eleven of those taken from the cage were put one inch below the surface in fresh soil, and a partial solution of 24 grams (18,000 pounds per acre) of kainit in 80 c. c. of water poured on the surface.

Check cage 1 contained only ten live larvae. Some had no doubt escaped as one side of the pot was broken. The ten with fifteen fresh ones were placed in a new cage. In cage 2, twenty-three live larvae were found at various depths. Seven of these were placed with eighteen fresh ones in the same cage.

May 25, all the larvae in the check cages were alive. Experiment cage 1 contained twenty-three live larvae near the middle of the cage, and in cage 2, seventeen live ones were found near the bottom of the cage. The cages were now broken up.

Thus the results obtained from the experiment and check cages during seven months indicate that kainit has but little, if any, effect on wireworms in the soil even when applied in very large quantities, as from four to nine tons per acre.

It should be noted that these results are diametrically opposed to those obtained by Professor J. B. Smith of the New Jersey Experiment Station. In *Insect Life*, Vol. 4, Nos. 1 and 2, p. 45, which has just appeared as this bulletin is sent to the printer, Professor Smith says: "I have followed out my inquiries into the actions of certain fertilizers as insecticides, and am more than ever convinced that in kainit we have a powerful agent for the destruction of forms infesting sod-land. Where this material is used before planting corn even on old sod, cut worms and wireworms will do no injury. In addition I always advise fall plowing to give the winter a chance. Direct experiments in the laboratory show that *Elatér* larvae will die in soil that contains kainit, though it acts slowly and two weeks are required to produce a

complete result. The experiments will be given in detail elsewhere."

Notwithstanding this statement we are unwilling to modify our conclusions without knowing the details of Professor Smith's experiments. It is especially important to know in just what proportions the kainit was used. As this substance contains about 33 per cent. of salt, wireworms can doubtless be destroyed by it, if it be used in sufficiently large quantities. But as it costs about fourteen dollars per ton this is impracticable. The matter is really a very important one, as the manufacturers of this fertilizer are making much of its supposed insecticidal properties. And the farmers that are influenced by their representations (which though doubtless sincere, are in our belief not well founded) are spending much money in what can only be a futile effort to rid their land of these pests.

MURIATE OF POTASH.

This is a product of German mines and large quantities of it are exported to this country. It is our principal potash fertilizer and is the source of potash in many of the mixed fertilizers now used. As this fertilizer contains about 50 per cent. of pure potash, it is costly. The present price is about \$40 per ton. Its insecticidal properties have recently been discussed by entomologists; and some farmers report satisfactory results from its use against wireworms.

August 4, 1890, we began to test the effects of the substance on wireworms. Twenty larvæ were placed about $1\frac{1}{2}$ inches below the surface of the soil in a cage (Fig. 6) and 1.5 grams (1000 pounds per acre) of the muriate was spread on the surface, which was frequently sprayed with a hose.

August 18, fifteen live and five fungus-killed larvæ were found at various depths. The fifteen live ones were placed in fresh soil in which 1.5 grams (1000 pounds per acre) of the muriate was mixed. The soil was kept moist by wetting the moss about the pot instead of spraying the surface.

September 5, six live and four fungus-killed larvæ were found. No trace of the other five was seen. Nine fresh larvæ were placed with the six live ones from the cage in fresh soil in which $1\frac{3}{8}$ grams (750 pounds per acre) of the muriate had been mixed.

September 29, twelve live and two fungus-killed larvae were found. The twelve larvae were placed in fresh soil on the surface of which a solution of $1\frac{1}{8}$ grams (750 pounds per acre) of the muriate in 20 c. c. of water was sprinkled. The substance was quite readily dissolved by the water.

October 10, every larva was alive and this cage broken up. The muriate of potash had thus been applied in three different ways at the rate of 750 to 1000 pounds per acre, and its effect, if any, on the wireworms was slight.

October 13, having received a fresh lot of larvae, two experiment and two check cages were started. No seed was sown. In each cage, twenty-five larvae were placed, and the soil in each experiment cage contained 1.5 grams (1000 pounds per acre) of the muriate. The soil in the check cages was untreated.

November 3, each of the check cages contained twenty-four live larvae which were replaced in the same cages. Cage 1 was placed in the cold room, and cage 2 in the hot house for the winter.

In experiment cage 1, every larva was found alive, and they were placed in fresh soil in which 6 grams (4000 pounds per acre) of the muriate had been mixed.

Experiment cage 2 contained twenty-four live larvae and one killed by a fungus; the twenty-four live ones were placed in fresh soil in which 6 grams (4000 pounds per acre) of the fertilizer was mixed.

November 26, only the experiment cages were examined. Cage 1 contained twenty-four live larvae, mostly within an inch of the surface. These were placed on the surface of fresh soil in which 18 grams (12,000 pounds per acre) of the muriate was mixed.

In cage 2, all the larvae were alive and near the surface. 12 grams (8000 pounds per acre) of the muriate was mixed with fresh soil, and the live larvae were placed on the surface.

December 8, the experiment cages were again examined. In cage 1, only eleven live larvae were found; the others were probably killed by the muriate of potash, as they resembled those which were killed by salt. Twenty-five fresh larvae were placed in fresh soil in which 12 grams (8000 pounds per acre) of the fer-

tilizer had been mixed, and the cage was put in the cold room for the winter.

Cage 2, contained twenty-two live larvae. Six grams (4000 pounds per acre) of the muriate was mixed in fresh soil and twenty-five fresh larvae were placed in it. The cage was put in the warm room for the winter.

April 15, all the cages were examined. Experiment cage 1 contained twenty-four live larvae near the bottom of the pot. These were placed one inch below the surface in fresh, dry soil, and a solution of 24 grams (16,000 pounds per acre) of the muriate in 80 c. c. of water, was sprayed on the surface.

Check cage 1 contained only ten live larvæ. The others had probably escaped through a large crack in the side of the pot. The ten, with fifteen fresh ones, were placed in a new cage.

In experiment cage 2, eighteen live larvæ were found at various depths in the soil. These with seven fresh ones were placed just below the surface in fresh soil, on the surface of which 24 grams (16,000 pounds per acre) of the muriate was scattered.

In check cage 2, twenty-three live larvæ were found at various depths. These were replaced in the same cage. All the cages were watered frequently with a hose.

On May 15, experiment cage 1 contained eighteen live larvæ at various depths in the soil. Several dead ones resembling those killed by common salt were found. In experiment cage 2, twenty-four of the larvæ were found alive at various depths.

The check cages were not examined until May 25, when every larva was found alive. All the cages were broken up.

From these results with the muriate of potash, it will be seen that it has to be used at the rate of from four to six tons per acre to have any effect on the larvæ, and then it is not so effective as the cheaper kainit or the much cheaper common salt. Its use in such large quantities would also be very destructive to vegetation. Although a valuable fertilizer, it is too expensive an insecticide to use against wireworms.

LIME.

Lime has long been used as a fertilizer, and many report good results from its use on fields infested by wireworms. Usually the unslaked lime is thrown into heaps, covered with a few inches of soil, and allowed to slake slowly. When slaked it is spread

evenly over the surface. Some scatter the unslaked form over the surface and before it slakes plow it under, thus adding the burning effect of the slaking to any other effect the lime might have on the wireworms.

Our experiments with lime were begun October 13, 1890. The form of cage used, is described and figured on page 196. Twenty-five wireworms were placed in the soil, and one half an inch below the surface 12 grams (100 bushels per acre) of unslaked lime was placed. A check cage with twenty-five larvæ in untreated soil was started at the same time. Both cages were watered on the surface frequently.

November 3, the lime in the experiment cage had slaked but still remained in easily pulverizable chunks. All the larvæ were found alive near the bottom of the cage. These were replaced in the same cage in fresh soil in which 24 grams (200 bushels per acre) of unslaked lime was mixed.

Twenty-four of the larvæ in the check cage were found alive and returned to the same cage. This cage was then placed in the hot house and not disturbed until spring.

November 26, the experiment cage was examined, and ten live larvae found on the surface and the other fifteen alive in the soil. They were all placed on the surface of the same soil and the cage kept in the cold room until spring.

April 15, 1891, the check cage contained twenty-three live larvæ at various depth in the soil. A few stalks of grass were growing in the cage. Seven of the larvæ with eighteen fresh ones were placed in the cage.

In the experiment cage, twenty-two live larvæ were found at various depths. Evidently lime applied in this manner had no effect on the larvæ. The twenty-two larvæ were placed about one inch below the surface in fresh soil and 100 c. c. of the milk of lime, or strong lime water in which the sediment had been mixed, was poured on the surface. The sediment formed a thin coating over the soil.

May 25, all the larvæ were found alive in both the experiment and check cages. The cages were now broken up as it was evident that lime applied at the rate of even 200 bushels per acre, either slaked, unslaked, or as lime water, had no effect upon the wireworms.

CHLORIDE OF LIME.

Our experiments with this substance began November 21, 1890. Twenty-five larvæ were placed in a cage (Fig. 6) in the soil of which 12 grams (100 bushels per acre) of chloride of lime was mixed.

December 6, twenty-four of the larvæ were found alive and were placed in fresh soil in which 18 grams (150 bushels per acre) of the chloride had been mixed. The cage was kept in the hot house during the winter.

April 17, 1891, nothing but the remains of dead larvæ were found in the cage. Twenty-five fresh larvæ were placed in the cage in fresh soil in which 12 grams (100 bushels per acre) of the chloride was mixed.

May 25 every larva was found alive at various depths in the soil.

These last results show that chloride of lime is effective, but must be used at the rate of nearly six tons per acre. This would be destructive to vegetation, and its cost, probably \$100 per ton, would make it impracticable.

GAS LIME.

This is the refuse lime thrown out at gas works. When fresh it smells strongly of ammonia and sulphur, but becomes nearly odorless after exposure to the air for a few days. It costs but little, gas manufacturers often giving it away. When applied in its fresh state to vegetation it is very destructive, but many farmers both in England and in this country affirm that it frees the soil of wireworms and other insect life.

October 27, 1891, we got some gas lime fresh from the gas vat and began experiments to learn its effects upon wireworms. The lime was very odorous, and by placing it in an air-tight glass jar it was kept in a fresh condition for a long time. One check cage and two experiment cages like the one shown in figure 6 were started. Twenty-five larvæ were placed about one inch below the surface in each cage, and in each experiment cage 12 grams (8000 pounds or about 100 bushels per acre) of fresh refuse lime was scattered on the surface of the soil and covered with a thin layer. The cages were watered on the surface frequently.

November 12, all the larvæ in experiment cage 1 and the check cage were alive. Experiment cage 2 contained twenty-three live

larvæ and one dead larva which was of a dark brown color. All of the larvæ were found near the bottom of the pots. The live larvæ from the experiment cages were placed in fresh soil in which 24 grams (16,000 pounds per acre) of the fresh gas lime had been mixed. The larvae found in the check cage were replaced.

November 26, only 12 live larvae were found near the surface in experiment cage 1. As no trace of the other thirteen was found, they had probably escaped, for the cage was not sealed with plaster of Paris but packed around the edge with cotton batting. Thirteen fresh larvae with the twelve live ones were placed in fresh soil in which 30 grams (20,000 pounds per acre) of the fresh gas lime was mixed. The cage was put in the cold house for the winter.

In experiment cage 2, every larva was found alive and the soil was very wet. The larvae were placed in fresh soil in which 30 grams (10 tons per acre) of fresh gas lime was mixed, and the cage kept in the warm room during the winter.

The check cage was not examined at this time, but was put in the cold room for the winter.

April 15, 1891, in the check cage twenty-two live larvae were found at various depths in the soil. They were replaced.

Experiment cage 2 contained twenty live larvæ which were placed in fresh soil in which was mixed 120 grams (40 tons per acre) of fresh gas lime. In experiment cage 1, only three live larvæ were found and but few remains of others were seen. This was a very different result from cage 1 although the cages were under the same conditions, except that one was kept in the cold room and the other in the warm room during the winter. This difference of temperature has however made no perceptible difference in the other experiments, and as no chance for escape was seen, it seems probable that the larvae were killed by the lime. Sixty grams (20 tons per acre) of fresh gas lime was mixed with two inches of the surface soil in a fresh cage and twenty-five fresh larvae were placed on the surface.

May 25, nineteen live larvae were found in the check cage. Experiment cage 1 contained only ten and experiment cage 2 only eight live larvæ. They were found from one to two inches beneath the surface. Remains of the other larvae were found.

These results indicate that when gas lime is applied fresh and

at the rate of from twenty to forty tons per acre, it is partially effective against wireworms.

At the last examination of the cages, the lime had been in the soil about forty days and there was still a slight odor perceptible. An experiment was tried to determine whether the burning effects of the ammonia and sulphur had passed away sufficiently in this time to allow crops to be grown in the soil. Wheat was sown in the soil in the experiment cages, one of which contained 60 grams (20 tons per acre) and the other 120 grams (40 tons per acre) of the lime. The wheat germinated readily, and June 15 there was no indication that it was injuriously affected by the presence of such large amounts of lime in the soil.

On the whole, therefore, our experiments indicate that the killing properties of the gas lime soon pass away, and it has to be used fresh in such great quantities to be effective that, notwithstanding its cheapness, it is hardly practicable on large areas.

C. DESTRUCTION OF PUPÆ AND ADULTS. (CLICK-BEETLES.)

Having discussed the various remedial measures recommended for preventing seed from being attacked, and for the destruction of the larvae, we now take up the subject of the destruction of the pupae and adults. Our experiments have suggested that this may best be accomplished by Fall Plowing and Trapping.

I. FALL PLOWING.

It is with pleasure that we turn from the discussion of measures that give little or no promise of practical use to one that we believe is of great importance. For the results of our experiments convince us that much can be done towards checking the increase of wireworms by fall plowing.

This method has been recommended by various writers; and some farmers have reported good results from the practice of it. But we have been unable to find any satisfactory explanation, in writings on this subject, of the way in which fall plowing acts beneficially. It is true that explanations have been suggested, but we have not found among these suggestions what we believe to be the true one.

One writer* suggests that, by plowing before the first of September and keeping the ground perfectly free from all growing vegetation until winter, the worms that do not die from exposure and the attack of birds, will all perish of starvation before a crop is on the ground the following season. But we have shown in the preceding pages that during the season of the year indicated above wireworms feed but little even when abundantly supplied with food, and we have also shown under the head, Starvation by Clean Fallow, that wireworms can live far more than a year, and probably much longer, in soil in which nothing is allowed to grow. Perhaps by fall plowing some of the wireworms will be exposed to the attack of birds, but as these larvae bury themselves very quickly after such exposure, the benefit obtained in this way would be slight.

The explanation of the beneficial results that follow fall plowing we believe to be found in the following facts, which were brought out in our studies of the life history of our more common species of wireworms: Wireworms live for at least three years in the worm or larval state. In this state they cease feeding about November 1, and hibernate until spring. When the worms are fully grown they change to soft white pupae which resemble the beetle in form. This change takes place in the species that commonly infests field crops during the month of July.† The pupa state lasts only about three weeks, the insect assuming the adult form in August. But, strange to say, although the adult state is reached at this time, the insect remains in the cell in the ground in which it has undergone its transformations till the following April or May, nearly an entire year. With most insects only a very short time is required after the change from the pupa to the adult state, to allow the body to harden, and the insect to become fitted for active life. But in this case the quiescent period after the adult form is reached is not only of long duration but appears to be necessary to the life of the insect. For in

* Prof. Gillette, Bull. No. 5, Iowa Exp. Sta., May, 1889.

† In the case of one species (*Asaphes decoloratus*), this change takes place in the latter part of May. This species, however, constituted but 5 per cent. of the wireworms received from our correspondents.

every case where the soil in the breeding-cages was disturbed after the insects had transformed, the beetles perished.* The only way in which we have been able to rear active adults, has been to leave the soil in the breeding cages undisturbed from midsummer till the following spring.

This experience clearly indicates that by fall plowing we can destroy the beetles in the soil, and thus prevent their maturing and depositing eggs the following season. The plowing may be done at any time after July 20, for our experiments show that by that time all the mature wireworms have changed to pupae. After plowing, the soil should be well pulverized and kept stirred up so that the little earthen cells of the pupae and adults may be destroyed. If this thorough cultivation be continued for three or four weeks previous to September 20 in this latitude, wheat, rye, or grass may be sown. If the plowing is not done until after this date, the ground must necessarily remain in fallow until spring. However, we do not think it generally necessary for the farmer to thus lose the use of his land in fighting these pests.

Suppose for instance, a wheat or other grain field is badly infested with wireworms. The crop is usually harvested before August 15. Plow immediately to a depth of at least six inches,† then thoroughly pulverize the soil and keep it well stirred until about September 10; or in other words, prepare the soil for sowing winter wheat or rye. The soil will not lose much of its plant producing qualities by being kept well stirred at this season of the year, for it is before the fall rains when it is usually dry and warm and nitrification does not take place to a great extent. Of course many live larvae will still remain in the soil, but they will not attack the crop until spring when it has a good start and can better withstand the attacks of the pests. Where rye cannot be grown with profit it may be plowed under for manure in the spring. It has served its purpose of storing up the plant food given off by the soil after the fall rains and now this food can be given back to the soil.

* In the field, a few beetles thus disturbed would, no doubt, find secure hibernating places in the crevices of old decaying trees or under rubbish. This is probably true of *Melanotus communis* at least.

† Our breeding experiments indicate that all the pupae and adults are less than six inches from the surface of the soil.

Now let us suppose a farmer has a piece of old sod land, which is a favorite breeding ground for the wireworms, that is badly infested with the pests. After the hay is cut treat the soil to a short late summer fallow as just described when a grain crop is infested. It will require more labor to thoroughly pulverize and otherwise fit the soil for sowing in September, but if well done paying results in greatly decreasing the ravages of the wireworms will follow. Then sow to winter wheat, rye, or grass. If grass is sown another crop of hay may be cut the following season. As the worms do not thrive as well in compact soil, it is a good practice to roll the infested piece in the spring. No doubt it will require several, at least three, years by this method of short rotation of crops to render the soil comparatively free from wireworms as only the pupæ and adults are killed, while the one year old and two year old larvæ will be uninjured. But farmers who practice this culture tell us they are not troubled with the pests. The drain on the soil by such a rotation must be met by liberal quantities of well rotted manures and often a little commercial fertilizer. Thus the general plan of how and the time when to best fight the wireworms has been suggested, but the special crops to be used in rotation will be best known to the farmer who understands, better than we, his locality and the suitability of his soil for certain crops.

We earnestly recommend the method of short rotation of crops to farmers having land badly infested by wireworms for we believe our experiments show why it will rid the soil of them, and the experience of farmers who practice the method is that the soil is rendered comparatively free from the pests in this way.

2. TRAPPING.

Our experiments on preventing the ravages of wireworms by trapping were carried on in 1888 and 1889. Two methods were employed, trapping by baits, and by lanterns.

On trapping by baits.—Bulletin No. 3, November, 1888, of this Station contained a full account of our experiments on trapping by baits, but as the bulletin is nearly out of print we here give a summary of these experiments.

They were begun with a view to protect the seed and young plants in a corn field by furnishing the worms with other food.

The baits which consisted of sliced potatoes, wads of green clover, corn-meal dough, and corn-meal dough sweetened with sugar, were placed under boards in various parts of a badly infested corn field. The results were very different from what was expected, for instead of the wireworms being attracted to the baits, large numbers of click-beetles were found at the baits. A very few larvæ were attracted to the sweetened dough.

The clover attracted by far the larger number (65 per cent.) of the beetles. Twelve traps after being undisturbed for only three days yielded nearly 500 beetles; more than one half of which were *Agriotes mancus*, the adult of the species of wireworm which constituted 91 per cent. of those sent us by correspondents. Sweetened dough came next in order of efficacy, while the unsweetened dough and sliced potatoes were much less attractive.

Experiments were also tried to determine whether the beetles fly by day or by night. When the traps were examined in the evening, they yielded less than one half as many beetles as at the morning collection; indicating that the insects fly both by day and by night, but are more active in the night-time.

In another experiment, the clover bait was placed in shallow pie-tins and in deep cake-tins. The former were sunken into the ground so that their upper edge was even with the surface, while the cake-tins were placed on the surface. 87 per cent. of the beetles were found in the pie-tins, indicating therefore that although the beetles fly readily, they seek their food chiefly by running over the surface of the ground.

Several insects other than click-beetles were found in the traps. There were many ground-beetles (Family Carabidæ) which are among the most beneficial of the insect class.

Figure 13 represents the species *Pterosticus lucublandus*, most common in our State. But as these ground-beetles are predaceous, they were probably simply hiding in the traps, or were there preying on the insects attracted by the baits. It is not probable that they would be injured by the poisoned baits. The corn-meal dough attracted many specimens of the Indian Cetonia (*Euphoria inda*) and *Ips fasciatus*, both of which are injurious to corn and probably can be destroyed in this way. Figure 14 represents the Indian Cetonia and in Figure



FIG. 13.—A ground beetle, *Pterosticus lucublandus*.

15 *Ips fasciatus* is represented natural size and enlarged.

When it was found that large numbers of the click-beetles could be trapped with baits of clover and dough, experiments were begun to ascertain if the labor of collecting the beetles from the traps could not be saved. The baits were poisoned with the result that most of the beetles were destroyed, proving that they fed upon those substances and suggesting a practical method of combating them. The best results were obtained by dipping a small handful of freshly cut clover into Paris-green water and placing the bunches under boards in various parts of the field.



FIG. 14.—The Indian Cetonina, *Euphoria indica*.



FIG. 15.—*Ips fasciatus*, natural size and enlarged.

Our experience, as well as the general testimony of writers on this subject, shows that these insects are much more likely to do serious injury in land that has remained in grass a number of years, and upon low grounds, especially those of a peaty quality and of a black color. Sometimes, as in the field where the greater number of our experiments were conducted, nearly all of the insects present will be found in a limited area differing from the remainder of the field in one of these particulars. Under these conditions efforts to destroy the beetles will naturally be confined to these areas.

When we take into consideration the small amount of labor involved in distributing poisoned baits as described, and in renewing them once or twice per week during the early part of the summer, and consider also the large number of beetles that can be destroyed, many of them doubtless before they have laid their eggs, we feel warranted in earnestly recommending that these important pests be fought in this way,

On trapping by lanterns.—From May 1 to October 1, 1889, we kept a series of six trap-lanterns lighted every night, and each morning the insects which had been captured were removed. The lantern consisted of a common tubular lantern set on two bricks placed in a common milk pan which was set on a platform about three feet from the ground. The lantern was held in place by two cords extending from the edges of the platform through a hole in the top edge of the pan and then tied around the tubes of the

lantern. The pan was kept nearly full of water on the surface of which a thin film of kerosene oil was poured. The lanterns were all located either in large pastures or corn or oat fields, except one which was set in the centre of a fruit garden. The main object of the experiment was to determine what and how many insects, whether injurious or beneficial, would be attracted by the lights.

During the whole five months, only 80 specimens of click-beetles representing six genera and thirteen species were captured in the lanterns. The accompanying table shows what species were represented and the number of each taken during each month. For the determinations we are indebted to the kindness of Dr. Horn.*

	May.	June.	July.	August.
<i>Asaphes decoloratus</i>		8	10	
" <i>bilobatus</i>			6	2
" <i>brevicollis</i>		1	2	
<i>Drasterius dorsalis</i>				1
<i>Athous cucullatus</i>		1	4	2
" <i>rufifrons</i>		1		
<i>Melanotus exuberans</i>	6	7	4	
" <i>scrobicollis</i>	1	2		
" <i>communis</i>	3	13		
" <i>sagittarius</i>		1		
" <i>americanus</i>		1		
<i>Corymbites sulcicollis</i>		1		
<i>Dolopius lateralis</i>			1	

Not enough specimens were taken to enable us to draw any conclusions except that trap lanterns do not attract the click-beetles in sufficient numbers to be of practical importance. Probably most of the captures were accidental. Large numbers of other insects were taken however and they will be discussed in future bulletins.

*Two specimens were too badly injured for determination.

AGRIOTES MANCUS.

THE WHEAT WIREWORM.

This species, commonly known as the Wheat Wireworm, is probably the most numerous and most destructive kind of wireworm in our State; for of nearly ten thousand larvae received, mostly from correspondents in Lewis Co., it was found that 91 per cent. were of this species. In 1867, Dr. Fitch in his eleventh Report on the Insects of New York records it as the most common species infesting our grass lands. It has also been reported as destructive in Canada and some of the Western States.

Although the beetle was described in 1823, nothing was known of the life history of the species until 1867. Dr. Fitch then described what he rightly supposed to be the larva, and gave a few notes on the occurrence and habits of the species. In 1871, Mr. J. Pettit of Ontario* reared the adult; and his article is accompanied by detailed descriptions of the larva and pupa by Dr. Horn.

From our experiments begun in 1888, we have learned several other facts bearing on the life history of this species. We have not observed the eggs, and, so far as we know, no one has ever seen a click-beetle of any species deposit its eggs. The only eggs that have been seen were obtained from the ovaries of the female by dissection, except in one case where Dr. Fitch† caused a female (*Adelocera brevicornis*) to deposit her eggs abnormally by confining her in a bottle for several days. These eggs were oval, soft, smooth, opaque, white in color, and only $\frac{3}{100}$ of an inch (.076 mm.) in length.

In April, 1890, when many beetles were emerging in our breeding cages, (Fig. 6) we sowed three cages to grass and wheat; and 25 or 30 of the adults were placed in each cage with the hope that some of the females might lay eggs. Most of the beetles died in a few days, and none were ever seen in copulation nor depositing eggs. The cages were not disturbed until August of the following year during which interval vegetation was kept growing in the cages so as to afford food for any larvæ that might be developed; but at this time no trace of eggs or young larvæ could be found. So we can only say that it is the general opinion that

**Canadian Entomologist*, 1872, Vol. 4, p. 3.

†Eleventh Report, 1867, p. 67.

the eggs of click-beetles are laid in the spring in the earth close to the roots of plants.

The newly hatched larvæ must be very small, and, according to European writers, they grow very slowly. The smallest larvæ of the Wheat Wireworm we have seen were about 4 mm. in length. All variations in size occur at the same time up to a full grown larva which measures from 16 mm. to 19 mm. The larvæ are quite slender, cylindrical, somewhat flattened on the venter, sparsely hairy, and of a waxy yellow color, lighter at the sutures. The anal segment tapers gradually to a subacute brown point, and bears on the dorsal aspect near the cephalic border two large conspicuous, brown, eye-like depressions resembling the breathing pores. By these, the Wheat Wireworm of any size may be readily separated from any other species which we have found infesting fields.

The larvae crawl quite rapidly, and having such smooth, horny bodies they are enabled to bury themselves in the soil very quickly whenever they are brought to the surface by the plow. As the larva increases in size, it casts its skin, how many times we do not know. This moulting process takes place in the burrows. The old skin opens at the sutures on the top of the head and along the median line on the dorsum of the three or four following segments, and the larva gradually works itself out. It is at first very tender and white in color, but soon hardens and turns to its normal waxy yellow color.

How long this insect remains in the wireworm state we cannot say with certainty. It is the general European opinion, based upon experiments made more than a century ago, that wireworms are five years in reaching maturity. But American writers are inclined to believe that the larval state lasts but three or even two years in this country. Dr. Fitch in his Eleventh Report says that the larvæ were readily separable into two sizes, the smaller ones about one half as large as the larger ones, indicating them to be respectively one and two years old. We have not found this rule to hold good. It was impossible to separate a large number of the larvae of any species into groups according to their size, for every gradation occurred. Furthermore, when the larvæ were separated into two or three lots graded as near as possible according to size, and then were placed in cages, we found, in

one case, that 1 per cent. of 200 of the smallest larvae (6-10 mm. long), 12 per cent. of 450 of the medium sized larvae (11-14 mm. long), and 40 per cent. of 450 of the largest larvae (15-18 mm. long) changed to pupae in about two months from the time they were placed in the cages. This fact shows that some of the smallest and medium sized larvae must have increased in size very rapidly, or, what is more probable, the mature larvae differ considerably in size. Thus, one cannot draw accurate conclusions as to the age of a Wheat Wireworm, at least from its size.

Mr. Pettit in his article already mentioned says that in the fall he found the larvae of the Wheat Wireworm readily separable into two sizes, and the largest ones remained in his cages until the following year before changing to pupae. Hence he concluded that the larval state does not last longer than three years.

Our breeding experiments have given us some data bearing on this point. May 10, 1889, we put 100 of the smallest (6-10 mm. in length) Wheat Wireworms we had in a cage sown to timothy and clover. July 11, 1889, the larvae were removed and used for other experiments, 20 being placed in a cage of growing brown mustard. The cage was examined but once during that year, August 26, and then only eleven larvae remained alive. These were replaced in the cage, and on April 28 of the following year the number of live larvae had been reduced to four. These were placed in a fresh cage, and the cage was examined five times during the year, May 30, July 10, Aug. 7, Sept. 6, Oct. 10, and Dec. 2. There was at the last date but a single live wireworm in the cage. This larva was also alive on April 21, 1891. It was then replaced in the cage and was still alive on July 9, 1891, two years and two months after we first placed it in our breeding cages. The cage was unwittingly broken up at this time and no note made of the size and appearance of the larva, so that we are unable to say whether the larva would have changed to a pupa or not that season. If it had been left in the cage a month longer and had not pupated, one more year must have been added to the wireworm period. But, as we learn from our notes that the larva was nearly full grown in December of the preceding year, it is quite probable that it would have pupated during July, 1891. In May, 1889, this larva was no doubt nearly a year old for it was then at least one third grown (6 mm. long), too large to have

been hatched the same spring. Again, we know that it lived for two years and two months afterward.*

Therefore, from these facts we conclude that the larval state in the case of the species under consideration lasts at least three years. However there is a possibility that the larva may have been two years old when we received it for they grow very slow. Measurements made of larvae in our cages at intervals of six months show that they increase only about 2 mm. in length during that period.

Again, it is barely possible that the larva would not have pupated during 1891, which would thus add one year to its age and make the duration of the wireworm state five years. This is only a possibility, not a probability.

Judging from the above considerations and from the fact that nearly one third of our larvæ that lived, pupated the same year that they were received, we are of the opinion that the Wheat Wireworm troubles the farmer but three years before resuming the beetle state.

Several interesting points regarding the habits of wireworms have also been brought out in our experiments with the Wheat Wireworm. We found that as the summer advanced the worms became less active and destructive, and finally about November 1, they ceased feeding and descended further into the soil. It is quite probable that the larvae cease feeding somewhat earlier in the field than they would in our cages in the Insectary. These facts accord with the general experience that crops suffer less and less from the larvae as the season advances. To what depth they descend in the fall, we cannot say further than that they were found near the bottom of the cages which contain about six inches of soil. If disturbed during this period of hibernation which lasts until spring, the larvæ were found to be very sluggish. The soil in the cages frequently became frozen solid but this did not seem to affect the larvae.

This long fast of five or six months sharpens their appetite, for in the spring they come toward the surface and do more damage to crops than at any other time. The larvae usually feed

*Mr. B. D. Walsh in *Practical Entomologist*, Vol. II, p. 61, says that a larva of *Ludius antennatus*, which was quite large when he obtained it, remained for two years in his breeding-jar before changing to the beetle.

quite near or even upon the surface. One of our correspondents who sent us thousands of the larvæ said that they could be most readily obtained by simply scratching the surface of his mucky sod land with a hook. We feed our larvæ in the Insectary by scattering upon the surface of the soil wheat into which they soon bore.

Large numbers of the larvæ become full grown and transform to pupæ each season. As this change takes place during the month of July and as the pupæ do not eat, we have another reason why crops suffer less in the latter part of the season. In the case of the Wheat Wireworm nearly one third of those received in May pupated in July of the same year.

It is the general opinion that the mature larvæ descend a considerable depth into the soil when about to pupate. We have seen no indication of this in our experiments. Pupæ were invariably found less than six inches below the surface, sometimes within an inch of the surface, even when there was fifteen inches of soil below them into which they might have descended.

About July 1, the mature larva makes an earthen cell in which it changes to a pupa. To make this cell the larva rolls over and over, moving the caudal half of its body in a circle at the same time. This crowds back and packs the particles of soil until a small, smooth, oval cell is formed with no silk or cement to support its wall. Larvæ which were disturbed at this time were found to have invariably lost the use of their legs, and were unable to bury themselves again. In many cases the larvæ in these cells had a wide, white stripe along the sides. Within a few days after the cell is formed, the change to a pupa takes place. This change is effected in the same manner as when the larva moults; the larval skin splits down the dorsum and the pupa works its way out.

The pupa is of a pure white color, very soft, and about one fourth longer than the beetle which it resembles in general appearance. The mouth parts are distinct, and the antennæ, wing pads, and legs are folded closely upon the breast. Nine segments are visible on the abdomen, and projecting from each angle of the thorax there is a long, sharp, fleshy bristle.*

*For description in detail see *Canadian Entomologist*, Vol. 4, 1872, p. 6.
(5)

July 10 is the earliest date that we have found pupæ in our cages. They were the most numerous about the middle of the month, and some were still in the pupa state on August 20. Adults were first found July 31, thus making the duration of the pupal stage about three weeks. The pupæ remain during this time in the little earthen cell made by the larva, and so tender are they that when removed from the cell it requires the most careful nursing in artificial cells to get them through this critical period.

By September 1, all the pupæ have transformed to beetles. For a few days after this change the beetles are of a yellowish white color and nearly as tender as the pupæ. Before winter sets in, however, the body walls and wing-covers attain their normal hardness and color. The beetle is about 8 mm. in length, robust in form, and of a dark brown color. The body is closely punctured and clothed with fine, short, incumbent hairs of a dull yellowish brown color. Each wing-cover has nine longitudinal striæ formed by deep oblong punctures. The thorax is very convex and each caudal angle is prolonged into a sharp spine. The head is inclined almost vertically, with the mouth parts situated on its inferior surface and applied to the prosternum in repose. The antennæ are filiform. From the fact that the front part of the head is truncated behind the labrum, the beetle has been called the Truncated Snapping-Beetle.*

These adults of the Wheat Wireworm remain in the little earthen cells during the whole winter. None ever came to the surface in our cages the same fall unless the soil was disturbed and their cells injured. Adults thus disturbed, when placed on the surface of loose soil, never buried themselves but soon died; and when they were placed one and one half inches below the surface, they soon worked their way to the surface and died.

Early in the spring the beetles leave their winter homes and work their way to the surface of the soil. In our cages kept in a cold room, they began to emerge April 10, and all had not emerged by April 26. The beetles are not very active during the day, and usually remain in secluded places. They were found to be the most active in our breeding cages after 4:00 P. M.

*For detailed description see Fitch. Eleventh Report, p. 72; Thomas. First Report, p. 118 (Quotes Say's original description).

Our trapping experiments also showed that they are most active in the night-time. They fly well and can run quite rapidly. When disturbed they quickly draw their legs close to the body, drop from their support and remain quiet for some time.

Curtis in "Farm Insects" says the beetles resort to flowers for food. We found in our trapping experiments that they sought the clover baits chiefly by running over the surface of the ground, and they ate the leaves only as the blossoms had not yet appeared. They also ate sweetened dough and sliced potatoes.* On April 28, in one of our breeding cages, we saw a beetle eating a kernel of wheat. Thus the beetles seem to be quite general feeders.

How long the adults live after emerging, we have not ascertained. They died in a few days in the confinement of our cages. Harris and Fitch say they are to be found among the roots of grass, on the under side of boards or stones on the ground, and sometimes on fences or weeds. Our trapping experiments indicated that they are especially numerous during the months of May and June. The beetles provide for the perpetuation of the species by laying eggs. But when and where these are laid still remains one of nature's secrets.

Larva.—Subcylindrical in form; dorsum slightly more convex; and lateral fold prominent. Length, when full grown, 16mm. to 19 mm. Color waxy yellow; a narrow band of light brown rings each segment near the caudal border; mandibles and cephalic margin of the head black shading into the general color of the head. Head flattened; and with long brown hairs arising from pits on the sides. The clypeus (Fig. 16 *a*) with the caudal portion fusiform, the caudal part of this portion narrower than the cephalic part; cephalic margin of the clypeus with a moderately prominent, three-toothed lobe on the median line; the teeth on this lobe are short, rather blunt, and of equal length. Labrum apparently wanting, being entirely within the cavity of the mouth. The mandibles (Fig. 16, *b*) are large, arcuate, moderately bifid at the tip, and bear a short, acute median tooth on the mesal side. The cardo of the maxillae (Fig. 16, *c*) have on their lateral aspect an elongated portion which is of a much darker color than the rest; the stipes regularly diminish in width toward the proximal end which is rounded. The sides of the gula (Fig. 16, *d*) are nearly parallel, this part being but slightly narrowed towards its base; the base is rounded with one long hair arising from a deep pit near each lateral angle. Prothoracic segment subquadrate and nearly as

*Cornell University Experiment Station, Bulletin No. 3, pp. 34-39.

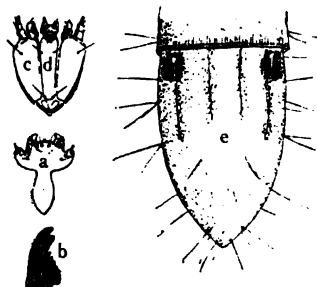


FIG. 16. — Larva of *Agriotes mancus*: a, clypeus; b, mandible; c, maxilla; d, gula; e, caudal segment.

long as the other two thoracic segments. The remaining segments of the body are of nearly uniform length and about two thirds as long as wide. The caudal segment (Fig 16, e) tapers uniformly to a subacute point tipped with brown; on each side of the segment near the cephalic margin there is a large deep depression, elliptical in outline and bordered by a slightly raised brownish black margin; extending caudad from each of these pits is a short dark brown linear impression; two similar impressions mark the dorsum between the pits; long brown hairs are regularly arranged on the sides.

venter and caudal extremity of the segment; the semi-circular fold around the anal proleg is rounded like a cord; the base of the proleg is finely striate. The prosternum gradually narrows to a rounded point caudad. The thoracic legs are short and stout; each joint armed with short brown spines. Spiracles large, oval, brown; there is a single thoracic pair situated on the second thoracic segment on the inflexed portion just in front of the coxae; there are eight abdominal pairs each situated near the cephalic border of the segment. Surface of body shining, and marked with minute, shallow, irregular pits; the caudal and cephalic border of the first thoracic segment and the caudal border of all the other segments except the last are minutely, longitudinally, striated. A depressed median line extends along the dorsum. Body sparsely clothed with long brown hairs; the hairs are arranged in rows near the cephalic and caudal margins of the segments; these rows begin in the subdorsal region on each side and extend over the lateral fold to the subventral region; in each row there are four or five prominent hairs and two or three shorter ones.

ASAPHES DECOLORATUS.

About 5 per cent. of the wireworms which we have examined during the past two years belonged to this species. Although this indicates that the larvæ are not very numerous, the species is widely distributed for the beetle is known to occur all over the northern states east of the Mississippi river.

So far as we know, nothing has heretofore been known regarding the habits and life history of the species. Most of our larvae were taken from old sod land; a few were obtained in a cultivated field. They ranged in length from 7 mm. to 25 mm. They are considerably flattened in form, and are of a dark, waxy-yellow

color with the head and following segment slightly darker. The segments are about twice as wide as long, sparsely hairy, and slightly constricted at the sutures. The caudal segment is much flattened and has a large oval shaped caudal notch formed by two rather long, flattened projections, each of which terminates in two short, blunt, horny, diverging tubercles. The dorsum of the segment is bounded by a narrow ridge which at the sides of the segment bears four distinct, blunt, horny tubercles. All of the tubercles bear one or two long, brownish hairs. The area bounded by the ridge is convex cephalad, roughened, bears no hairs, and is marked by a deep roughened linear depression on each side and a short mesal impression extending from the middle of the area to the caudal notch.

We have found cast skins of the larvae in our cages but have not ascertained when or how many times they moult. In moulting, the sutures on the top of the head open, the skin splits along the median line of the dorsum of the thoracic segments, and the larva gradually works itself out. It is probably white and tender for some time after moulting as in the case of the Wheat Wireworm.

On one occasion a large larva was seen with a smaller one held between its jaws. This suggested that the larvae might be partially carnivorous, so we tried to rear some on animal food.*

An experiment and a check cage (Fig. 6) were made. In the soil of the former, 41 wireworms and 10 earth-worms were placed, and no seed sown. In the check cage, which was sown to clover and timothy, 41 wireworms were also placed. The cages were examined three times at intervals of two weeks and we failed to find any indications that the wireworms had attacked the earth-worms. As the larvae have lived in our breeding cages containing no animal food for nearly a year, it is quite probable that the cannibalistic habit observed was accidental, and that the normal food of the larvae is the living grass root.

*Several species of wireworms are said to be carnivorous. "Dr. Riley has reared *Hemirhipus fascicularis* from larvae preying on those of *Cyllene pictus*; *Elatér luctuosus* from larvae that fed on those of *Dendroides canadensis* and *Cucujus clavipes*; *Melanotus communis* from a black oak badly infested with *Chrysobothris femorata*." (First Rept. U. S. Entomological Commission, 1877, p. 304). He has also found the larva of *Drasterias amabilis* preying on locust eggs. (American Entomologist, Vol. 3, 1880, p. 247).

We have insufficient data upon which to base an opinion in regard to the duration of the wireworm period of this species. Every gradation in size appeared among the larvae. But the fact that about one third of the larvae received in May pupated the same season, would indicate that the wireworms reach maturity in three years.

As the larvae mature in May, it is quite possible that they continue feeding all winter. During the latter part of May and the first part of June the larvae make oval earthen cells in the soil about three eighths of an inch long. This is done by the larva rolling over and over in its burrow, thus pushing back and packing the particles of earth into a smooth hard wall. Within these cells the change to a pupa takes place. We have not seen the pupa. On June 27, adults were found on the surface of the soil in some of the cages. The larvae had been placed in the cages May 13. Thus in one month and a half after the larvae were received, they had made their cells and changed to pupae; the pupae had transformed into adults; and these adults had attained their normal color and hardness and had worked their way to the surface. Evidently then the pupal stage is not longer than four weeks.

The beetle varies from 9 mm. to 15 mm. in length. It is of a shining blackish color with brown legs. The body is rather slender, closely punctured, and clothed with fine, short, incumbent, grayish brown hairs. The wing-covers are moderately deeply striated, with the intervening spaces rounded and finely punctured. The mouth parts are situated on the anterior portion of the head, the front of which is slightly concave and not margined by a raised ridge back of the labrum. The antennae are filiform. The second and third joints of the tarsi are lobed beneath.*

Some of the beetles had not emerged from the soil by July 4, but none were found alive in the soil after this date. This indicates that all the adults emerge before fall, but of the further history of the species, we know nothing.

The beetles may, as do some species, crawl into crevices in the bark of trees or into other secluded places and there remain dur-

* For detailed descriptions see Say, in Trans. Am. Phil. Soc., 1836, Vol. 6, p. 180 (original description); and Horn, in Trans. Am. Ent. Soc. 1880, Vol. 8, p. 73.

ing the winter. If so, the eggs are probably not laid until spring. If the beetles do not hibernate, the eggs are laid in the summer or fall and the winter is then passed either in the egg or young larval state.

Larva.—Sub-cylindrical in form; considerably flattened; dorsum slightly more convex; and lateral fold prominent. Length, when full grown, 20 mm. to 25 mm. Color dark waxy yellow; mandibles and cephalic margin of head black shading gradually into the dark brown color of the head. Head flattened; and with long brown hairs arising from deep pits on the sides. The clypeus (Fig. 17, *a*) with the caudal portion fusiform, the cephalic part of this portion narrower than the caudal part; cephalic margin of clypeus with a large, prominent, three-toothed lobe on the median line; the mesal tooth of this lobe is larger and longer than the others; on some specimens these teeth are more or less worn off. Labrum apparently wanting, being entirely within the cavity of the mouth. The mandibles (Fig. 17, *b*) are large, arcuate, and bear a short curved median tooth on the mesal side. The maxillae (Fig. 17, *c*) have the cardo strongly bilobed; the stipes very slightly diminish in width toward the proximal end which is truncate. The sides of the gula (Fig. 17, *d*) are nearly parallel, this part being but slightly nar-

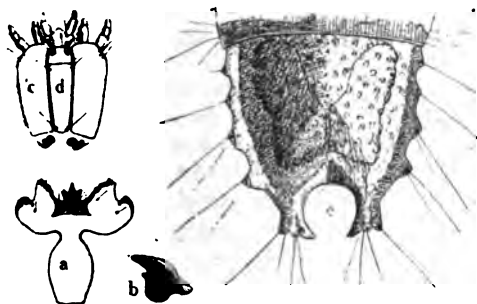


FIG. 17.—*Larva of Asaphes decoloratus*; *a*, clypeus; *b*, mandible; *c*, maxilla; *d*, gula; *e*, the base is rounded, with one long hair arising from a deep excavation near each lateral angle. Prothoracic segment subquadrate and nearly as long as the other two thoracic segments. The remaining segments of the body of nearly uniform length, slightly constricted at the sutures, and almost twice as wide as long. The caudal segment (Fig. 17, *e*) is considerably flattened, and has a large oval caudal notch formed by two rather long flattened projections each of which curves slightly dorsad and terminates in two short, blunt, horny diverging tubercles; the two inner tubercles project dorso-mesad, with a small hair-bearing tubercle arising from the lateral aspect; the outer tubercles project nearly directly dorsad. The dorsum of the segment is bounded by a narrow ridge which on the sides of the segment bears four short, distinct, blunt, horny tubercles, the more caudal one being considerably larger. The area bounded by this ridge is convex cephalad, slightly roughened, bears no hairs, and is marked by a deep, roughened, linear depression on each side and a short mesal linear impression extending from the middle of the area to the caudal notch; ventral portion of the seg-

mented toward its base; the base is rounded, with one long hair arising from a deep excavation near each lateral angle. Prothoracic segment subquadrate and nearly as long as the other two thoracic segments. The remaining segments of the body of nearly uniform length, slightly constricted at the sutures, and almost twice as wide as long. The caudal segment (Fig. 17, *e*) is considerably flattened, and has a large oval caudal notch formed by two rather long flattened projections each of which curves slightly dorsad and terminates in two short, blunt, horny diverging tubercles; the two inner tubercles project dorso-mesad, with a small hair-bearing tubercle arising from the lateral aspect; the outer tubercles project nearly directly dorsad. The dorsum of the segment is bounded by a narrow ridge which on the sides of the segment bears four short, distinct, blunt, horny tubercles, the more caudal one being considerably larger. The area bounded by this ridge is convex cephalad, slightly roughened, bears no hairs, and is marked by a deep, roughened, linear depression on each side and a short mesal linear impression extending from the middle of the area to the caudal notch; ventral portion of the seg-

ment slightly wrinkled ; the semi-circular fold around the anal pro-leg extends upon the base of the leg in the form of a thin finely striated margin ; the distal margin of the joints of the leg are similarly striated. The prosternum is triangular, and acutely wedge-shaped caudad. The thoracic legs are short and stout ; each joint armed with short brown spines. Spiracles large, elongate oval, brown ; there is a single thoracic pair situated on the second thoracic segment on the inflexed portion just in front of the coxæ ; there are eight abdominal pairs, each situated near the cephalic border of the segment. Surface of the body shining, nearly smooth on the thoracic segments and on the venter ; the dorsum of the abdominal segments is marked with numerous shallow transverse notches, and a slight dark ridge which crosses the segment near the cephalic border, then curves suddenly, extends obliquely caudo-ventrad on each side and nearly meets a faint impressed line extending across the segment. The caudal and cephalic margins of the first thoracic segment and the caudal margin of the other segments, except the first and last, are marked by numerous fine longitudinal striae. A linear mesal depression ending abruptly near the caudal border of each segment, extends along the dorsum. Body sparsely clothed with long yellowish brown hairs ; a row of from 18 to 22 hairs extends around the body from one subdorsal line to the other near the caudal border of each segment except the head and last segment ; two similar hairs arise near the cephalic margin of the segments, one dorsad and the other ventrad of each spiracle ; the lateral and caudal tubercles on the anal segment have one or two long hairs arising from their sides, and other hairs arise from the pro-leg and from small tubercles on the venter of the segment.

MELANOTUS COMMUNIS.

This species of wireworm is quite common in our fields, more especially in the cultivated portions. Fifty-five per cent. of a lot of larvæ, picked up while planting corn in Lewis Co., were of this species. While less than 3 per cent. of those obtained from sod land by another correspondent in the same county belonged to this species. Dr. Fitch said in 1867 that it was the most common wireworm met with in our gardens. The species has also been reported injurious to corn in Illinois.

Nothing has been recorded of the life history of the species, except a few notes on the adults, and Dr. Fitch's short account * of the occurrence and habits of the beetles, accompanied by a

*Fitch. Eleventh Report on Insects of New York 1867, p. 72-74.

description of what he rightly supposed to be the larva.*

Our breeding experiments were begun in the spring of 1889. At this time the larvæ varied in length from 5mm to 20mm. They are subcylindrical in form, nearly smooth, shining, and of a light brown color, with the head, thoracic and last segments considerably darker, and the venter and margins of the segments, lighter in color. Body sparsely hairy, and each segment marked on the sides just dorsad of the spiracles with a linear impression. The cephalic border of the segments is slightly elevated and rendered distinct from the rest of the segment by a wavy dark border. Touching this border, on each side of the dorsum of the segments, is a large, dark, elliptical, striated, muscular impression. The caudal segment is much flattened, has no caudal notch, but ends in a short, blunt, horny tubercle. On each side of this tubercle the margin is very obtusely notched, forming two wave-like projections. The dorsum of the segment is much roughened and marked by four linear impressions near the cephalic border, and a similar mesal depression on the dorsum near the caudal extremity.

Our larvæ lived in breeding cages (Fig. 6) containing growing grass, and we saw no indications of any carnivorous tendency. However, Dr. Riley says he has bred this species from Black Oak badly infested with *Chrysobothris femorata*, the Flat-headed Apple-tree Borer.†

The duration of the larvæ period is at least three years. For several large larvæ were placed in a cage May 30, 1889, and some changed to adults that year, but one larva kept growing for nearly two years, reaching a length of 30 mm. It died in the spring of the second year and was no doubt at least three and possibly five years old. In one case, a larva which was only 11 mm. long when placed in a cage April 25, 1889, changed to a beetle that year. At another time four larvæ measuring 20 mm. May 3, changed to beetles the same year. These facts indicate that the mature larva differs considerably in size, and some may be longer in attaining maturity than others.

*The wireworms reported as working in the grains of planted corn and described by Dr. Thomas in his Second Illinois Report, 1877, p. 26, probably belonged to this species. It is there named the Corn Wireworm.

†First Report U. S. Entomological Commission, 1877, p. 304.

The change to a pupa takes place during July. The mature larva forms an earthen cell similar and probably made in a similar manner to the cell of the Wheat Wireworm. This cell is about three fourths of an inch in length and three eighths of an inch wide. Soon after the cell is finished the skin of the larva opens at the sutures on the top of the head and along the median line on the dorsum of the following 3 or 4 segments. The white and tender pupa then works itself out leaving the cast larval skin crowded into one end of the cell. The wing-pads, legs, and antennæ of the pupa are folded closely on the breast. In other respects it resembles the beetle, but is nearly one fourth longer and the nine segments of the abdomen are distinctly visible. It is much larger than the pupa of the Wheat Wireworm, and in addition to the long sharp bristle at each angle of the thorax it has two similar shorter ones, one each side the mesal linear depression near the caudal border of the thorax.

The change to a beetle takes place in about one month. The rather slender, glossy, dark brown beetle varies from 11 mm. to 15 mm. in length, and its body is closely punctured and clothed with fine, short, incumbent, greyish hairs. The wing-covers are striated by deep oblong punctures, the intervening spaces flat and minutely punctured. The mouth parts are on the anterior portion of the head, and the front is slightly flattened but distinctly margined back of the labrum. The antennæ are reddish brown and serrate. A smooth, shallow, impressed line extends along the mesal portion of the thorax. The tarsi are not lobed beneath and the claws are pectinate.*

In our cages the beetle never left its earthen cell until the following spring. In 1885, Prof. Forbes reared the closely allied species, *Melanotus cribulosus*, and found that the adult remains under ground for hibernation.†

These facts would indicate that the beetles pass the winter in the ground. But Dr. Harris says that the recently transformed beetles may be found in autumn under the bark of trees, where they pass the winter.‡ Dr. Fitch also says that the beetles are

*For detailed description see Fitch. Eleventh Report, p. 72; Say. Trans. Ann. Phil. Soc. vol. 4, p. 184.

†Forbes. Miscellaneous Essays on Economic Entomology, 1885, p. 17.

‡Harris. Insects Injurious to Vegetation, Flint Ed., p. 55.

most abundant during the months of April, May and June. Their numbers then diminish and only a few are to be found in August, but they are again quite numerous in September and the following months. As cold weather approaches, they crawl under the loose bark and into the crevices of old and decaying trees, or under stones and wood on the ground, and there pass the winter.*

The normal place of hibernation for the adult is, no doubt, in the soil. But, as the species occurs more commonly in cultivated fields, its cell would in many cases be destroyed by the fall cultivation of the soil, and the beetle would thus naturally be forced to seek such secluded places as the crevices of the bark of trees, etc., in which to pass the winter. As many of the beetles would be disturbed before they had attained their normal color and hardness, the fact of their being found by Dr. Harris in a recently transformed state under the bark of trees, would thus be accounted for.

The beetles in our cages kept in a cold room began to emerge about May 1. In the spring and summer, says Dr. Fitch, the beetles are most commonly met with in places in the garden where a dense foliage like a strawberry bed affords a hiding place for them; also among the grass in pastures and meadows, on the leaves of apple and other fruit trees, and on the leaves of oak, birch, and other forest trees.

The eggs are no doubt laid in the spring or summer but the secret of the life history of the species from the emerging of the beetles to the appearance of the one fourth grown wireworms yet remains with Nature.

Larva.—Subcylindrical in form; dorsum slightly more convex; and lateral fold prominent. Length, when full grown, 20 mm. to 25 mm. Color light brown, with the venter and the caudal and cephalic margins of the segments lighter brown; head, dorsum of the thoracic segments, and caudal segment

*Fitch. Eleventh Report on Insects of New York, 1867, p. 72-73.

considerably darker; mandibles and cephalic margin of the head black shading gradually into the dark brown color of the head. Head flattened; and with long brown hairs arising from deep pits on the sides. The clypeus (Fig. 18, *a*) with the caudal portion fusiform, the caudal part of this portion narrower than the cephalic part; cephalic margin of the clypeus with a broad rounded lobe on the median line; between this lobe and the cephalo-lateral portion which bears a brush of hairs there is on each side a conspicuous blunt tooth. Labrum apparently wanting, being entirely within the cavity of the mouth. The mandibles (Fig. 18, *b*) are large, arcuate, and bear a short, blunt, curved, median tooth on the mesal side. The maxillae (Fig. 18, *c*) have the cardo strongly bilobed; the stipes regularly diminish in width toward the proximal end which is rounded. The sides of the gula (Fig. 18, *d*) are nearly parallel, this part being but slightly narrowed toward its base; the base is obtusely wedge-shaped and usually with two hairs near each lateral angle. Prothoracic segment subquadrate and nearly as long as the other two thoracic segments. The remaining segments of the body are of nearly uniform length and almost twice as wide as long. The caudal segment (Fig. 18, *e*) is much flattened, concave, roughened above, and ends in a short, blunt, horny tubercle; on each side, the segment is very obtusely notched forming two wave-like projections. The cephalic portion of the dorsum of the segment is marked by four, linear, longitudinal impressions, the two inner ones diverging cephalad, the outer ones nearly parallel and beginning near the middle of the dark muscular impressions at the cephalic border of the segment; on the caudal half of the segment there is a single deep linear impression on the middle line; ventral portion of this segment slightly wrinkled; the semi-circular fold around the anal pro-leg is rounded like a cord; the base of the pro-leg is finely striate. The prosternum is bluntly rounded caudad. The thoracic legs are short and stout; each joint armed with short brown spines. Spiracles large, elongate oval, brown; there is a single thoracic pair situated on the second thoracic segment on the inflexed portion just in front of the coxæ; there are eight abdominal pairs, each situated near the cephalic border of the segment. Surface of the body shining, nearly smooth. The cephalic and caudal borders of the abdominal segments are finely, longitudinally striate. The cephalic border of each segment except the prothoracic, is slightly elevated and rendered distinct from the rest of the

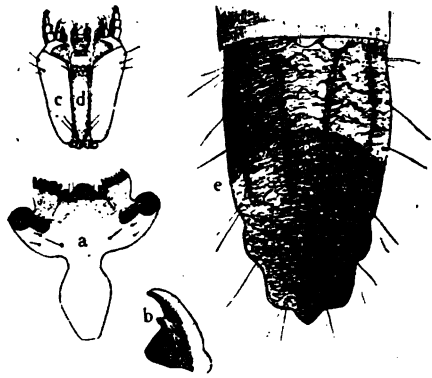


FIG. 18.—Larva of *Melanotus communis*; *a*, clypeus; *b*, mandible; *c*, maxilla; *d*, gula; *e*, caudal segment.

h e prothoracic, is slightly elevated and rendered distinct from the rest of the

segment by a notched dark border; this elevated portion is usually nearly covered by the caudal margin of the preceding segment, especially on the venter, and is obsolete mesally on the thoracic segments. Touching the border of this elevated cephalic border near the lateral margin, there is a large dark, elliptical, longitudinally striated, muscular impression; from the ends of these impressions nearest the spiracles on the abdominal segments, a distinct linear impression extends caudad for about one half the length of the segment, and nearly meets a faint linear impression extending across the dorsum. A linear mesal impression extends along the dorsum on both thoracic and abdominal segments. Body sparsely clothed with long yellowish brown hairs; a row of 12 to 15 hairs extends around the body from one subdorsal line to the other near the cephalic border of each segment; two long hairs with a short one near the base of each arise from the sides near the caudal border of each segment; and a long and a short hair arise near each other on each side just ventrad of the lateral fold near the caudal border of each segment; quite a number of hairs arise from the sides, extremity, and venter of the anal segment; a row of short hairs extends across the segment just cephalad of the pro-leg.

DRASTERIAS ELEGANS.

This species of wireworm is widely distributed over the country, and has been reported as exceedingly abundant and injurious to young wheat in Indiana.* We found the larvæ quite abundant in April in sod land on the University farm.

The larvae are small, 9 mm. to 12 mm. in length, sparsely hairy, and considerably flattened in form, tapering slightly toward the extremities. The body is of a light waxy-yellow color, with the head and following segment considerably darker. A deep linear mesal impression extends along the dorsum. The mandibles are rather large and not toothed. The caudal segment is much flattened and has a nearly heart-shaped caudal notch formed by two, short, broad projections that curve upward, each of which terminates in two, short, blunt, horny, diverging tubercles. The dorsum of the segment is bounded by an narrow ridge which, at the sides of the segment, bears five or six short horny tubercles. The oval area bounded by this ridge is strongly convex cephalad, and deeply concave caudad. This area is marked by two distinct, linear impressions diverging slightly cephalad from which many fine wavy wrinkles radiate. The pro-leg is large, hairy, and has

*F. M. Webster. U. S. Division of Entomology, Bull. No. 22, p. 52.

no raised ridge around its base, but the segment is deeply excavated just back of it.

Dr. Riley says the wireworms of this genus are known to be carnivorous,* but we have seen no indications of such a habit among our larvae which lived and transformed in a cage (Fig. 6) containing growing grass.

The larvae were placed in the cage April 24, and were not disturbed for over two months. On July 4, recently transformed beetles were found in earthen cells in the soil. On the moulting habits of the larva, on the formation of the cell in the soil, on the pupa, or on the duration of the pupa state, we have made no observations. The change to a beetle takes place about July 1, but whether the beetles emerge soon, as in the case of *Asaphes decoloratus*, or whether they hibernate in the ground we cannot say.

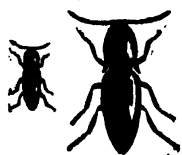


FIG. 19. — *Drasterius elegans*, adult natural size and enlarged.

The beetles (Fig. 19) measure from 6 to 7 mm. in length, and are of a general rusty brown color with black markings; the head, venter of abdomen, a large fusiform spot on the dorsum of the thorax, a large oblong spot on the cephalic portion of each wing cover, and a wide sinuate band across the caudal portion of the wing covers are blackish; the antennae and legs are yellowish brown. The body is closely punctured and clothed with fine, short, incumbent, yellowish hairs. The wing covers are striated by rather deep oblong punctures, the intervening spaces nearly flat and minutely punctured. The margin of the front of the head is elevated behind the labrum, and the prosternum is moderately wide with double, outwardly concave sutures.†

Many of these beetles were collected in our trap experiments with clover baits in 1888.‡

Larva.—Subcylindrical in form; considerably flattened; dorsum slightly more convex; segments slightly constricted at the sutures; the body tapers towards each extremity, the head and anal segment being a little more than one half as wide as the middle portion of the body. Length, when full grown, 9 mm. to 12 mm. Color light waxy-yellow; head and first thoracic segment light brown; mandibles and cephalic margin of the head black shading grad-

*American Entomologist, vol. 3, p. 247; U. S. Entomologist's Report for 1886, note p. 580.

†For detailed description see Say's Entomology, v. 2, p. 108.

‡Cornell Univ. Agr. Exp. Station, Bull. 3, p. 35.

ually into the dark brown color of the head. Head flattened; and with long brown hairs arising from rather deep pits on the sides. The clypeus (Fig. 20, a) with the sides of the caudal portion nearly parallel and slightly notched,

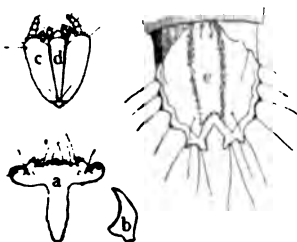


FIG. 20.—Larva of *Drasterius elegans*; a, clypeus; b, mandible; c, maxilla; d, gula; e, caudal segment.

20, d) regularly converge to a sharp point at the proximal end; two hairs arise from round pits near the base. Prothoracic segment subquadrate and nearly as long as the other two thoracic segments. The remaining segments of the body of nearly uniform length and a little more than twice as wide as long. The caudal segment (Fig. 20, e) is considerably flattened, and has a nearly heart-shaped caudal notch formed by two, short, broad projections that curve upward, each of which terminates in two, short, blunt, horny, diverging tubercles. The dorsum of the segment is bounded by an narrow ridge which, at the sides of the segment, bears five or six short, horny tubercles, the more caudal one or two being larger. The oval area bounded by this ridge is convex cephalad, and quite deeply concave caudad; the area is marked by two distinct, linear, longitudinal impressions, diverging slightly cephalad, from which many fine wavy wrinkles radiate; long hairs arise from the sides of the tubercles, from the venter, and there is one on each side of the meson on the dorsum near the caudal notch; the anal pro-leg is large, very prominent, sparsely hairy and has no ridge around the base but the segment is deeply excavated just caudad of it. Prosternum acutely wedge-shaped. The thoracic legs are short and stout; each joint armed with short brown spines. Spiracles oval, slightly darker than the body in color; there is a single thoracic pair situated on the second thoracic segment on the inflexed portion just in front of the coxae; there are eight abdominal pairs, each situated near the cephalic border of the segment. Surface of the body shining and nearly smooth. A deep linear mesal impression ending quite abruptly near the caudal border of each segment, extends along the dorsum. Each abdominal segment is marked in the subdorsal region by an elongate impression, and on the venter by a broad V-shaped impression opening cephalad. The caudal and cephalic margins of the first thoracic segment, and the caudal margin of the other segments except the first and last, are marked by numerous fine longitudinal striae. Body sparsely clothed with long yellowish brown hairs; on the dorsum there

are two or three in a row on each side of each segment near both the caudal and cephalic margins ; the lateral fold bears two or three on each segment ; and on the venter near the lateral fold there is one or two hairs near both the cephalic and caudal margins.

CRYPTOHYPNUS ABBREVIATUS.

We met with a few wireworms of this species in old sod land. Although the beetle was described in 1823, nothing has since been recorded concerning its life history.

The worms when mature are from 7 mm. to 9 mm. in length, and closely resemble the young larvæ of *Asaphes docoloratus*. They are of a dark, waxy-yellow color ; and considerably flattened in form. The segments of the body are almost twice as wide as long, sparsely hairy, but not constricted at the sutures. The caudal segment is much flattened, and has a circular caudal notch formed by two short flattened projections each of which terminates in two dark, rather long, sharp, horny, widely diverging tubercles ; the two inner tubercles nearly meet, and a minute hair-bearing tubercle arises from their lateral aspect ; the dorsum of the segment is irregularly wrinkled, and is bounded by a narrow ridge which, on the sides of the segment, bears four, very short, blunt, horny tubercles of nearly the same size ; the area bounded by this ridge is convex cephalad, and bears six hairs four near the cephalic border ; and two near the middle of the area the lateral and caudal portions of this area are concave.

The larvæ were placed in cages (Fig. 6) of growing grass in the spring and were not disturbed until fall ; some remained undisturbed until the next spring. In October one cage contained live beetles in their earthen cells ; and in the following May a beetle emerged in another cage. These facts indicate that the larvæ undergo their transformations during the latter part of the summer and the beetle which is produced normally hibernates in the soil, appearing on the surface early in the spring.

The beetle is brownish-black with a greenish-bronze surface luster. It is about one fourth of an inch in length and its robust, closely punctured body is sparsely clothed with fine, short, incumbent, yellowish-brown hairs ; near the tip of the wing-covers there is a large spot of denser pubescence. The wing-covers are moderately deeply striated with the intervening spaces flat and

finely punctured. The margin of the front of the head is raised above the labrum. The hind coxal plates are suddenly dilated inward; the tarsal claws are small and not toothed. The prosternal sutures are single, straight and nearly parallel. The thorax is convex, narrowed in front, and has a distinct mesal impression the whole length of the dorsal surface.*

The beetles are not uncommon throughout the northern part of North America from Nova Scotia westward to Oregon; and from New York northward to Alaska.

Larva.—Subcylindrical in form; considerably flattened; dorsum slightly more convex; and lateral fold prominent. Length, when full grown, 7 mm. to 9 mm. Color dark waxy-yellow; mandibles and the cephalic margin of the head black shading into the general color of the head. Head flattened; and with long brown hairs arising from moderately deep pits on the sides. The clypeus (Fig. 21, *a*) with the caudal portion broadly fusiform, the cephalic part of this portion considerably broader than the caudal part; cephalic margin

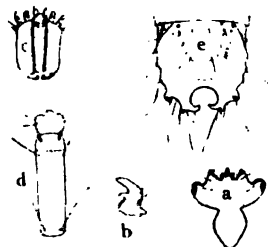


FIG. 21.—*Larva of Cryptohypnus abbreviatus*; *a*, clypeus; *b*, mandible; *c*, maxilla; *d*, gula; *e*, caudal segment.

of the clypeus with a large, prominent, three-toothed lobe on the median line; the mesal tooth of this lobe is much larger and longer than the others. Labrum apparently wanting, being entirely within the cavity of the mouth. The mandibles are large, arcuate and bear a short recurved median tooth on the mesal side. The maxillae (Fig. 21, *c*) have the cardo strongly bilobed; the stipes very slightly diminish in width toward the proximal end which is truncate. The sides of the gula (Fig. 21, *d*) are nearly parallel, this part being but slightly narrowed toward its base; the base is rounded with one long hair arising from a rather deep excavation near each lateral angle. Prothoracic segment subquadrate and nearly as long as the other two thoracic segments. The remaining segments of the body are of nearly uniform length, not constricted at the sutures, and almost twice as wide as long. The caudal segment (Fig. 21, *e*) is considerably flattened, and has a large circular caudal notch formed by two short flattened projections each of which curves slightly dorsad and terminates in two, dark, rather long, sharp, horny, widely diverging tubercles; the two inner tubercles project mesad, curve slightly dorsad at the tips, and a minute hair-bearing tubercle arises from the lateral aspect of each; the outer tubercles project nearly directly dorsad. The dorsum of the segment is irregularly wrinkled and is bounded by a narrow ridge

*For detailed description see, — Horn, Transactions Am. Ent. Soc. 1891, Vol. 18, p. 7.

which, on the sides of the segment, bears four very short, blunt, horny tubercles of nearly the same size; the area bounded by this ridge is convex cephalad, bears six hairs, two near the middle of the area and four short inconspicuous ones near the cephalic border; the lateral and caudal portions of this area are concave; ventral portion of the segment slightly wrinkled; the semi-circular fold around the anal pro-leg extends upon the leg in the form of a thin finely striated margin; the distal margin of the joints of the leg are similarly striated. The prosternum is triangular and acutely wedge-shaped caudad. The thoracic legs are short and stout; each joint armed with short brown spines. Spiracles, large, brown, oval; there is a single thoracic pair situated on the second thoracic segment on the inflexed portion just in front of the coxae; there are eight abdominal pairs, each situated near the cephalic border of the segment. Surface of the body shining, and marked by many minute punctures. On the dorsum of the abdominal segments, an indistinct, darkish, wavy, linear ridge crosses the segments near the cephalic border, then curves suddenly obliquely caudo-ventrad on each side, thus forming a slightly impressed quadrangular area on the dorsum. The caudal and cephalic margins of the first thoracic segment and the caudal margin of the other segments, except the first and last, are marked by numerous fine longitudinal striae. A linear mesal impression extends along the dorsum of the body. Body sparsely clothed with long yellowish-brown hairs; a row of from 18 to 22 hairs extends around the body from one sub-dorsal line to the other near the caudal border of each segment except the head and last segment; two similar hairs arise near the cephalic margin of the segments, one dorsad and the other ventrad of each spiracle; the lateral and caudal tubercles on the anal segment bear one or two long hairs, and other hairs arise from small tubercles on the venter of the anal segment.

JOHN HENRY COMSTOCK.
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CORNELL UNIVERSITY

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COMBINATIONS OF FUNGICIDES AND INSECTICIDES, AND SOME NEW FUNGICIDES.

I. EXPERIMENTS AT CORNELL.

The necessity of spraying in order to protect many of our cultivated plants from insects and fungi is now an established fact. Fruit growers particularly suffer from these enemies, for there is scarcely one of the fruits commonly grown which has not several enemies that do serious damage.

The substances which are applied for the protection of foliage and fruit may be divided into two classes: 1st, those which are directed against fungi; 2nd, those directed against insects. It is the common practice to apply these separately, since when combined they are supposed to have an injurious effect upon the plant. The value of a combination which would be equally effective against insects and fungi can hardly be overestimated for it would do away with almost one-half of the operations which are now necessary to obtain a good crop of fruit.

Early in the year a series of experiments was planned to determine what the action of various combinations would be upon plants, fungi and insects. Careful notes were taken at regular intervals, and I am under obligations to Professor Creelman, of the Agricultural College of Mississippi, who was with us during the summer, for assistance in this respect. The results obtained are undoubtedly more accurate than they would have been had only one observer taken them.

The compounds of copper are probably the most valuable for destroying fungi, and these were used for that purpose in the combinations. The arsenites are the most effective substances for the destruction of insects and they were applied in connection with the fungicides.

Every solution which is applied in a spray against fungi or insects should, so far as possible, possess the following qualities :

1. It must be effective.
2. It must not injure the plant.
3. It must be easy to apply.

These essential points were kept in view when making the formulas, for every solution which does not possess them must be more or less imperfect. All the liquids were more easy to apply than the Bordeaux mixture.

The arsenites used were Paris green and London purple. Equal amounts of these were applied in many cases so that a comparison could be made. The London purple contained 72 per cent. of the normal arsenite of calcium, over 50 per cent. of which was soluble in water.*

Paris green and London purple were not applied stronger than is recommended†, except in the case of the peach. Larger quantities of the London purple may have been used in a few cases, but practically all injury which resulted from the applications, with the exception of the peach in some cases, must be due to the fungicides, or to the united action of the insecticide and fungicide.

The applications were made to branches of apple, peach, quince, and grape ; rows of potatoes and egg plants were used, others being kept as checks. Only three applications were made to egg plants ; this was more than was required to destroy the insects. The foliage of the potatoes began to die about the middle of August, so that no definite observation could be made later. All applications were made with a knapsack pump and Vermorel nozzle ; the combinations were mixed immediately before being applied.

None of the plants were attacked by fungi except quinces, so that it was only upon these that some of the combinations could be tested as fungicides. Potatoes and egg plants were used to determine what action the combination would have upon insects.

The intention was to spray about every 10 days, but as much rain fell in July the applications were made more frequently. Heavy showers occurred Aug. 4 and 13, probably washing a considerable part of the solution which had been applied from the

*See N. Y. Cornell Sta. Bull. xviii.

†See Mich. Bull. 53. Iowa, Bull. No. 10. Ind. Bull. 34.

foliage. Much rain fell after the last applications, which occurred Aug. 19, 21, and 25.

CARBONATE OF COPPER (COMMERCIAL) AND ARSENITES.

The carbonate of copper is one of our most valuable fungicides. When dissolved in ammonia it is more easily applied than the Bordeaux mixture, and is usually as effective. The ammoniacal carbonate of copper is generally made by dissolving 3 ounces of the carbonate in 1 quart of strongest ammonia, and diluting this with 22 gallons of water. This formula is recommended by most of the experiment stations; the solution has been tested upon all the plants used in these experiments, except the peach and the eggplants, and the foliage is not injured by its use.* As this fungicide was in no case applied stronger than is here given, any injury which may have followed the applications cannot be ascribed to the ammoniacal carbonate of copper alone, unless it is in the case of the peach.

The carbonate of copper was applied in twelve different combinations; the following tables show the amount of injury done by each:

No. 1. The ammoniacal carbonate of copper, 3 ounces of the carbonate dissolved in 1 quart† of ammonia and diluted with 22 gallons of water. Paris green at the rate of 1 pound to 200 gallons of water.

Dates of applications.	Plants used.	Dates of observation and per cent. of injury.			
		July 23.	Aug. 8.	Aug. 22.	Sept. 5.
July 13.	Apple (<i>Salome</i>)	0	0	5	10
" 22.	Pear (<i>Seckel</i>)	0	5	10	20
" 27.	Quince (<i>Angers</i>)	0	0	5	5
Aug. 10.	Peach (<i>Old Mixon Free</i>)	40	70	80	100
" 20.	Grape (<i>Catawba</i>)	0	5	5	10
	Eggplant	0	0	0	.....
	Potato (<i>June Eating</i>)	20	25	...	.....

*See Conn. Annual Report 1890, p. 99. U. S. Dept. Agric. Report 1890, p. 398,399; Report of 1889, p. 403. Ill. Bull. No. 16, p. 492.

†The ammonia used in all the experiments was very strong—26° Baumé.

No. 2. The ammoniacal carbonate of copper as in No. 1. London purple at the rate of 1 pound in 200 gallons of water.

Dates of applications.	Plants used.	Dates of observation and per cent. of injury.			
		July 23.	Aug. 8.	Aug. 22.	Sept. 5.
July 13..	Apple (<i>Salome</i>).....	0	0	10	20
" 22..	Pear (<i>Clapp</i>).....	0	0	10	10
" 27..	Quince (<i>Meech</i>).....	0	0	20	30
Aug. 10..	Peach (<i>Old Mixon Free</i>).....	40	60	80	80
" 20..	Grape (<i>Diana</i>).....	0	0	10	10
	Eggplant.....	0	0	0	...
	Potato (<i>June Eating</i>)... ..	30	30	...	...

The action of these two solutions as fungicides was determined upon the quinces. The Angers is more susceptible to the attacks of the fungus (*Entomosporium maculatum*) with which the trees were effected, than other varieties. The Meech was much more free from the disease, but still there was enough present to show the effect of the applications. September 9 the sprayed branch of the Angers retained all its leaves and but little of the disease was present upon them. The rest of the tree was almost defoliated, and the leaves which still remained were badly affected. During October about one half of the leaves from this treated branch fell, while other treated branches of the same variety retained their foliage. None of the leaves of the Meech were badly diseased, but still the sprayed branch was plainly healthier than the rest of the tree. This branch also lost some of its leaves during October, but not so many as the Angers.

When these two combinations (Nos. 1 and 2) were applied to potatoes and eggplants, the potato beetles were as thoroughly exterminated as though no fungicide had been used in connection with the arsenite.

In each case the foliage of the quince was injured by the solutions, but not so much as to cause any of the leaves to fall before the middle of October. Nor was the apple much injured by the treatment, for none of the leaves dropped; the parts injured were principally those upon which the solution gathered after application, as the edges and ends of the leaves. Very little injury

was done to the central surface, and the same is also true of the pears, grapes, and potatoes. Eggplants were not injured. Peaches suffered the most. All the leaves were shed and the shoots were in several places burned so severely that the sap exuded, and some of the twigs died. The Paris green combination was more injurious to peaches and pears, than that with London purple, while the later combination injured the apple, quince, and potato more. No difference could be seen on grapes.

No. 3. The ammoniacal carbonate of copper, $1\frac{1}{2}$ ounce of the carbonate dissolved in $\frac{1}{2}$ quart of ammonia and diluted with 22 gallons of water, and Paris green at the rate of 1 pound in 200 gallons of water.

Dates of applications.	Plants used.	Dates of observation and per cent. of injury.			
		July 23.	Aug. 8.	Aug. 22.	Sept. 5.
July 13.	Apple (<i>Salome</i>)	0	0	5	10
" 22.	Pear (<i>Clapp</i>)	0	5	10	10
" 27.	Quince (<i>Angers</i>)	0	0	0	0
Aug. 10.	Peach (<i>Old Mixon Free</i>)	0	70	80	100
" 20.	Grape (<i>Does</i>)	0	20	30	30
	Eggplant	0	0	0	...
	Potato (<i>June Eating</i>)	10	20	...	...

No. 4. The ammoniacal carbonate of copper as in No. 3. London purple at the rate of 1 pound in 200 gallons of water.

Dates of applications.	Plants used.	Dates of observation and per cent. of injury.			
		July 23.	Aug. 8.	Aug. 22.	Sept. 5.
July 13.	Apple (<i>Salome</i>)	0	0	5	10
" 22.	Pear (<i>Clapp</i>)	0	0	0	0
" 17.	Quince (<i>Meech</i>)	0	0	0	5
Aug. 10.	Peach (<i>Crawford</i>)	20	20	70	80
" 20.	Grape (<i>Geneva</i>)	0	0	10	10
	Eggplant	0	0	0	...
	Potato (<i>June Eating</i>)	10	10	...	...

By comparing these two tables with the two preceding, it will be seen that less injury was done to the plants than by combina-

tions 1 and 2 with the exception of the grape in one instance. The difference in the grapes may be due to the varieties. Combination No. 3 was more injurious than No. 4 to all the plants except the quince, which was uninjured by the former, as was the pear by the latter.

The action of these two combinations upon the fungus of the quince was even more marked than of the first two. The sprayed branches showed scarcely any disease Sept. 5, although the remainder of the Angers tree had lost most of its leaves, and the leaves of the Meech were badly affected. At the date of writing, Nov. 12, the foliage of both branches still persists, and in the case of the Angers the sprayed leaves are the only ones upon the tree, excepting the younger ones which appeared after the first set had fallen. From this it would appear that the beneficial action of the ammoniacal carbonate of copper as a fungicide is not diminished by the addition of either London purple or Paris green, for its action is practically the same when no arsenite is added; it is also to be observed that the weak copper combination gave better results than the strong combination in Nos. 1 and 2. Nor was the effect of the arsenite lessened, for when the combination was applied to the potato vines and eggplants, the beetles were as thoroughly exterminated as when no fungicide had been applied in connection with the arsenites. Consequently it would appear that when the ammoniacal carbonate of copper is applied in connection with London purple or Paris green, the action of neither the carbonate nor the arsenite is weakened.

No. 5. The ammoniacal carbonate of copper, 3 ounces dissolved in 1 quart of ammonia and diluted with 22 gallons of water, and Paris green at the rate of 1 pound in 300 gallons of water.

No. 6. The ammoniacal carbonate of copper as in No. 5, London purple at the rate of 1 pound in 300 gallons of water.

In most respects the results obtained by the use of these combinations are very similar to those of the stronger solutions 1 and 2, except in the case of apples. Their average injury is 30 per cent. greater than that which resulted from the first two combinations. The variety here used was Seek-no-further, and this is probably the cause of the difference. Solution No. 5 injured apple foliage about 30 per cent. more than No. 6. The sprayed branch

of the quince was again the best on the tree, and the potato beetles were killed as before.

No. 7. The ammoniacal carbonate of copper, $1\frac{1}{2}$ ounces dissolved in $\frac{1}{2}$ quart of ammonia and diluted with 22 gallons of water, and Paris green at the rate of 1 pound to 300 gallons of water.

Dates of applications.	Plants used.	Dates of observation and per cent. of injury.			
		July 23.	Aug. 8	Aug. 22.	Sept. 5.
July 11.	Apple (<i>Seek-no-further</i>).....	0	0	30	50
" 27.	Pear (<i>Clapp</i>)	0	10	15	15
Aug. 10.	Quince (<i>Meech</i>).....	0	0	0	5
" 20.	Peach (<i>Crawford</i>)	50	...	60	60
	Grape (<i>Geneva</i>).....	5	10	30	30
	Eggplant.....	0	0	0	...
	Potato (<i>June Eating</i>).....	0	0	...	...

No. 8. The ammoniacal carbonate of copper as in No. 7. London purple 1 pound to 300 gallons.

Dates of applications.	Plants used.	Dates of application and per cent. of injury.			
		July 23.	Aug. 8.	Aug. 22.	Sept. 5.
July 11.	Apple (<i>McIntosh Red</i>).....	0	0	0	5
" 27.	Pear (<i>Clapp</i>)	0	5	10	15
Aug. 10.	Quince (<i>Meech</i>).....	0	0	0	0
" 20.	Peach (<i>Crawford</i>).....	0	20	40	80
	Grape (<i>Geneva</i>).....	0	5	10	10
	Eggplant.....	0	0	0	...
	Potato (<i>June Eating</i>).....	0	0	...	...

Although these two combinations are little more than one half as strong as Nos. 1 and 2, still the amount of injury done is about as great. The most remarkable difference between these two tables appears in the case of the apple. No. 7 injured 50 per cent. of the foliage of *Seek-no-further*, while only 5 per cent. of the foliage of *McIntosh Red* was injured by No. 8. All of this difference

can scarcely be due to the difference in the combinations applied ; it is undoubtedly owing to the fact that one variety can better withstand the injurious action of the combinations than the other. The difference between the quinces is not so great, but the Paris green combinations again injured the trees more than that containing London purple.

No. 9. Carbonate of copper in suspension in water, 3 ounces to 22 gallons of water. Paris green at the rate of 1 pound to 200 gallons of water.

No. 10. Carbonate of copper as in *No. 9.* London purple 1 pound in 200 gallons of water.

No. 11. Carbonate of copper in suspension, $1\frac{1}{2}$ ounces in 22 gallons of water. Paris green at the rate of 1 pound in 200 gallons of water.

No. 12. Carbonate of copper as in *No. 11.* London purple 1 pound in 200 gallons of water.

These combinations also injured the foliage considerably. The McIntosh Red apple and the Clapp pear were uninjured by *No. 9.* 30 per cent. of the foliage of the same variety of apple was injured by *No. 10.* The injury to the pear foliage averages about 7 per cent. for the four combinations, and that of the quince only 5 per cent.; grapes $12\frac{1}{2}$ per cent., being about equally injured by each solution. Peaches suffered more by *Nos. 10 and 12*, these killing some twigs; but even the least injured branch lost 40 per cent. of its leaves.

The action of these four combinations upon the fungus of the quince was not marked. Some branches seemed to be benefitted and others not, but none remained so healthy as those treated by *Nos. 2 and 4.* As insecticides they were as effective as any of the preceding combinations.

The data regarding the action of these twelve combinations upon foliage, show that when Paris green is applied with the ammoniacal carbonate of copper the action of the combination is more caustic than when London purple is used. Also, that the addition of London purple to water holding the carbonate of copper in suspension forms a more caustic combination than when Paris green is added. In making out the following table of injuries sustained, only those varieties were considered which were treated with both arsenites, thus making the conditions in each

case the same. The numbers denote the average per cent. of injury:

	Am. carb. of copper and Paris green.	Am. carb. of copper and London purple.	Carb. of cop- per in susp. and Paris green.	Carb. of cop- per in susp. and London purple.
Apple	27	20	0	30
Pear	12	8	5	15
Quince	7	2	5	5
Peach	80	74	60	100
Grape	30	15	10	20
Potato	15	12	0	0

In every instance ammoniacal carbonate was more caustic with Paris green than with London purple.

These results were unexpected, and could not be accounted for until a chemical analysis of the solutions had been made. Mr. Cavanaugh, assistant chemist to the station, found that the ammoniacal carbonate of copper will dissolve practically twice as much Paris green as London purple.

The larger amount of dissolved arsenic in the Paris green combinations is undoubtedly the cause of the greater injury done by them.*

When these arsenites were applied with the carbonate of copper suspended in water, the combination containing London purple was more caustic in every case excepting that of the quince; potatoes were uninjured by either one.

Conclusions.—When the ammoniacal carbonate of copper is applied in connection with London purple or Paris green, the action of neither the insecticide nor the fungicide is weakened.

The ammoniacal carbonate of copper gave better results as a fungicide when used at the rate of $1\frac{1}{2}$ ounce dissolved in one pint of ammonia, and diluted with 22 gallons of water, than when 3 ounces of the carbonate and 1 quart of ammonia were used to the same amount of water.

The fungicidal action of the carbonate of copper suspended in water is not marked.

* See Bull. N. C. Exp. Sta. No. 77 b.

Even though the ammoniacal carbonate of copper, and the carbonate of copper in suspension, may have no injurious action upon certain plants when used alone, if they are applied in connection with London purple or Paris green, although these are also used in safe quantities, the combined action of the two seriously injures the foliage of some of our cultivated plants. Even when both the fungicide and the insecticide are considerably diluted, the injurious action is in many cases serious.

Paris green with the ammoniacal carbonate of copper is more caustic than is an equal amount of London purple.

When London purple is applied in connection with carbonate of copper held in suspension in water, the combination is more caustic than one in which an equal amount of Paris green is used.

Some varieties of certain fruits are apparently more susceptible to injury from the preceding combinations than others.

None of the above combinations of the ammoniacal carbonate of copper with Paris green in London purple can with safety be used upon the plants treated in this series, with the exception of eggplants.

The injury done to foliage by the above combinations is undoubtedly due to the arsenic which is dissolved by the fungicide.

SULPHATE OF COPPER (COMMERCIAL) AND ARSENITES.

In order to test solutions of the sulphate of copper in water the following formulas were made. The tables show the results of the application :

No. 13. Sulphate of copper, $\frac{1}{4}$ pound dissolved in 22 gallons of water.

Dates of applications.	Plants used.	Dates of observation and per. cent. of injury.			
		July 23.	Aug. 8.	Aug. 22.	Sept. 5.
July 13.	Apple (<i>Alexander</i>).....	0	0	20	20
" 28.	Pear (<i>Howell</i>).....	0	0	10	20
Aug. 11.	Quince (<i>Champion</i>).....	0	0	0	0
" 20.	Peach (<i>Downton</i>).....	25	40	60	70
	Grape (<i>Moore's Early</i>).....	0	0	10	20
	Eggplant	0	0	0	...
	Potato (<i>Early Rose</i>).....	0	0	...	...

No. 14. Sulphate of copper, $\frac{1}{2}$ pound dissolved in 22 gallons of water.

Dates of applications.	Plants used.	Dates of observation and per cent. of injury.			
		July 22.	Aug. 8.	Aug. 22.	Sept.
July 13.	Apple (<i>Alexander</i>)	5	10	20	20
" 28.	Pear (<i>Howell</i>)	10	20	30	30
Aug. 11.	Quince (<i>Champion</i>)	0	0	0	0
" 20.	Peach (<i>Hardwick</i>)	50	60	80	80
	Grape (<i>Rochester</i>)	0	0	10	20
	Eggplant	0	0	0	...
	Potato (<i>Early Rose</i>)	0	0	...	...

These tables show that all the plants were injured except the quinces, eggplants, and potatoes, a result which was unexpected since the use of 1 pound of the sulphate of copper dissolved in 25 gallons of water has been recommended for mildew on grapes.

Two combinations were made with each of the above formulas, using Paris green and London purple at the rate of 1 pound in 200 gallons of water, with each one. The combinations containing Paris green caused on the average 20 per cent. more injury than when the arsenite was not used. The London purple combinations increased the injury of the sulphate only 10 per cent. As the varieties treated were not the same, this result cannot be regarded as conclusive. The effect of these solutions upon fungi was unsatisfactory.

Conclusions.—The action of the commercial sulphate of copper upon foliage is uncertain.

The injury done by the sulphate of copper solutions is increased from 10 to 20 per cent. by the addition of arsenites.

HYDRATE OF COPPER (FROM LABORATORY) AND ARSENITES.

Copper appears in the Bordeaux mixture in the form of the hydrate. The following shows the reactions which take place in preparing the Bordeaux mixture, and its final composition when prepared according to the formula :

6 pounds copper sulphate,

4 " lime,

22 gallons of water.

The following results were obtained by Mr. Snyder, formerly assistant chemist at the experiment station :

"In preparing the Bordeaux mixture the following reaction takes place :

$\text{Cu SO}_4 + \text{Ca (OH)}_2 = \text{Ca SO}_4 + \text{Cu (OH)}_2$. Both of these new products are insoluble in water. If both the lime and sulphate of copper are chemically pure, it would require 1 pound of lime to combine with 4 pounds of copper sulphate ($\text{Cu SO}_4 + 8 \text{ H}_2\text{O}$). A qualitative examination of the filtered solution showed a small amount of copper hydrate (trace), calcium sulphate, due to the extreme dilution of the solution, and calcium hydrate due to the excess of lime used in making the mixture. The Bordeaux mixture when ready for use has the following composition :

Calcium hydrate in solution.

" sulphate " "

Copper hydrate " " (trace)

" " precipitated.

Calcium sulphate precipitated."

Since the hydrate of copper is the active principle of the Bordeaux mixture, experiments were conducted to determine its value when applied alone.

No. 15. Hydrate of copper at the rate of $\frac{1}{2}$ pound in 22 gallons of water.

Dates of applications.	Plants used.	Dates of observations and per cent. of injury.			
		July 23.	Aug. 8.	Aug. 22.	Sept. 5.
July 17..	Apple (<i>Alexander</i>)	0.	0	0	0
" 28..	Pear (<i>Howell</i>)	0	0	0	0
Aug. 11..	Quince (<i>Champion</i>)	0	0	0	0
" 21..	Peach (<i>Downton</i>)	0	0	10	15
	Grape (<i>Oriental</i>)	0	0	0	0
	Eggplant	0	0	0	...
	Potato (<i>Early Rose</i>)	0	0	...	...

It will be seen that the peach was the only plant injured ; the leaves appeared as if punctured, the holes being from $\frac{1}{8}$ - $\frac{1}{4}$ in. in diameter.

The hydrate of copper was also applied at the rate of $\frac{1}{4}$ and $\frac{1}{8}$ pounds in 22 gallons of water. The results were the same as the above, except that the peach showed less injury.

No. 16. Hydrate of copper at the rate of $\frac{1}{2}$ pound in 22 gallons of water ; Paris green at the rate of 1 pound in 300 gallons of water.

Dates of applications.	Plants used.	Dates of observation and per cent. of injury.			
		July 23.	Aug. 8.	Aug. 22.	Sept. 5.
July 17.	Apple (<i>Longfield</i>).....	0	0	0	0
" 28.	Pear (<i>Howell</i>).....	0	0	0	0
Aug. 11.	Quince (<i>Champion</i>).....	0	0	5	5
" 21.	Peach (<i>Wheatland</i>).....	0	20	50	50
	Grape (<i>Moore's Diamond</i>)....	0	10	10	15
	Eggplant.....	0	0	0	...
	Potato (<i>Early Rose</i>).....	0	0	...	...

Here the addition of Paris green again causes a greater injury to the foliage, the quince and the grape as well as the peach being affected. The other plants were uninjured, and from this it would appear that the hydrate of copper may be of some value in combination with Paris green. For the action of hydrate of copper as a fungicide see page 331.

Conclusions.—The hydrate of copper when applied alone does little injury to the foliage, only the peach being affected.

When Paris green is added to the hydrate the combination is more caustic than when either is applied alone, the injury to the peach being much increased. The quince and the grape were also injured.

BORATE OF COPPER (FROM LABORATORY) AND ARSENITES.

Several combinations were made with the borate of copper to determine if it possesses any value as a fungicide, and to ascertain what its action would be when arsenites are added. This substance closely resembles the carbonate of copper and is insoluble

in water. For its value as a fungicide see page 331. The following tables show its effect upon foliage :

No. 17. Borate of copper at the rate of $\frac{1}{2}$ pound in 22 gallons.

Dates of applications.	Plants used.	Dates of observation and per cent. of injury.		
		Aug. 8.	Aug. 22.	Sept. 5.
July 21..	Apple (<i>N. Spy</i>).....	0	0	0
" 29..	Pear (<i>Hardy</i>).....	0	0	0
Aug. 20..	Quince (<i>Champion</i>).....	0	0	0
	Peach (<i>Globe</i>).....	10	10	20
	Grape (<i>Lady Washington</i>).....	0	0	5
	Eggplant	0	0	0
	Potato (<i>Early Rose</i>).....	0	...	...

The peach and the grape are the only plants injured.

No. 18. Borate of copper at the rate of $\frac{1}{2}$ pound in 22 gallons of water. Paris green 1 pound in 200 gallons of water.

Dates of applications.	Plants used.	Dates of observation and per cent. of injury.		
		Aug. 8.	Aug. 22.	Sept. 5.
July 21..	Apple (<i>N. Spy</i>).....	0	0	0
" 29..	Pear (<i>Seckel</i>).....	0	0	5
Aug. 21..	Quince (<i>Champion</i>).....	0	0	0
	Peach (<i>Globe</i>).....	20	30	40
	Grape (<i>Empire State</i>).....	0	10	20
	Eggplant	0	0	...
	Potato (<i>Early Rose</i>).....	0	...	...

The peach and the grape are again injured, and also the pear, showing that the addition of Paris green made the solution more caustic.

No. 19. The ammoniacal borate of copper, 3 ounces of the copper dissolved in 1 quart of ammonia and diluted with 22 gallons of water, and Paris green at the rate of 1 pound in 200 gallons of water.

Dates of applications.	Plants used.	Dates of observation and per cent. of injury.		
		Aug. 8.	Aug. 22.	Sept. 5.
July 21..	Apple (<i>Longfield</i>)	0	0	0
" 29..	Pear (<i>Summer Doyenne</i>)...	0	20	30
Aug. 11..	Quince (<i>Champion</i>)	0	10	20
" 21..	Peach (<i>Wheatland</i>)	30	60	100
	Grape (<i>Victoria</i>)	0	10	20
	Eggplant	0	0	...
	Potato (<i>Early Rose</i>)	0	...	...

These results are very similar to those obtained under formula No. 1, with the carbonate of copper. The apple was injured more by No. 1, the peach was affected as badly, but the other plants were injured somewhat more by No. 19. The borate combination, No. 18, injured the same plants as No. 9 with the exception of the quince, and it also injured the pear, making the actions of these two combinations also about the same, although more of the borate was used. The commercial borate of copper costs about 30 cents an ounce, but it is considerably cheaper by the pound.

Conclusion.—The action of the borate of copper upon foliage resembles that of the carbonate, both when applied with Paris green or with ammonia and Paris green.

CHLORIDE OF COPPER (COMMERCIAL) AND ARSENITES.

The chloride of copper is a greenish crystalline substance readily soluble in water. Its commercial value is about 10 cents an ounce, or 50 cents a pound.

This substance was also used in several combinations, but as its action upon foliage was entirely unknown the solutions were all made too strong. Later in the season it was tried again, reducing the quantities used. Its action upon fungi is shown on page 331. The following tables show the amounts of injury done to foliage:

No. 20. Chloride of copper, 1 ½ ounces in 22 gallons of water.

Dates of applications.	Plants used.	Dates of observation and per cent. of injury.	
		Aug. 22.	Sept. 5.
Aug. 20.	Apple (<i>Gravenstein</i>)	0	5
	Pear (<i>Sheldon</i>).....	0	0
	Quince (<i>Mammoth</i>).....	0	0
	Peach (<i>Mt. Rose</i>)	10	70
	Grape (<i>Gaertner</i>)	0	0
	Eggplant	0	0

No. 27. Chloride of copper, $1\frac{1}{2}$ ounce in 22 gallons of water, Paris green at the rate of 1 pound in 200 gallons of water.

Dates of applications.	Plants used.	Dates of observation and per cent. of injury.	
		Aug. 22.	Sept. 5.
Aug. 20.	Apple (<i>Gravenstein</i>).....	0	10
	Pear (<i>Sheldon</i>).....	5	5
	Quince (<i>Mammoth</i>).....	0	0
	Peach (<i>Mt. Rose</i>).....	10	90
	Grape (<i>Gaertner</i>)	0	0
	Eggplant	0	0

Although but one application was made, the first table shows serious injury to the peach, and the apple was also affected, but only slightly. The second table shows injury to the peach, apple, and pear, the addition of Paris green again making the solution more caustic.

Conclusions.—The chloride of copper must be used in small quantities.

Its caustic action upon foliage is increased by the addition of Paris green.

FUNGICIDAL VALUES OF THE NEW COMPOUNDS.

The hydrate, the borate, and the chloride of copper were applied to pumpkin and squash vines, which are usually attacked by mildew (*Oidium erysiphoides* var. *Cucurbitarum*), in order to deter-

mine their real value as fungicides more accurately than could be done upon the quinces. The Bordeaux mixture was used for comparison. Two applications were made, the first Sept. 8, the second Sept. 18. The solutions were made according to the following formula :

Bordeaux mixture, as on page 326.

Hydrate of copper. No. 1, $\frac{1}{2}$ pound in 22 gallons of water.

No. 2, $\frac{1}{8}$ pound in 22 gallons of water.

Borate of copper. No. 1, $\frac{1}{2}$ pound in 22 gallons of water.

No. 2, $\frac{1}{4}$ pound in 22 gallons of water.

Chloride of copper. No. 1, $1\frac{1}{2}$ ounce in 22 gallons of water.

No. 2, 3 ounces in 22 gallons of water.

None of these solutions appeared to injure the foliage. The following table shows what per cent. of the foliage was attacked by mildew Sept. 26, when the notes were taken.

As different varieties of cucurbits were sprayed each plot had its own check which contained some vines of the same variety as those treated.

Fungicides.	Per cent. injury treated.	Per cent. injury untreated.
Copper hydrate, No 1.....	25	25
“ “ “ 2.....	25	30
“ borate “ 1.....	30	50
“ “ “ 2.....	40	50
“ chloride “ 1.....	10	40
“ “ “ 2.....	5	40
Bordeaux mixture.....	5	30

The numbers showing the per cent. of injury to the foliage treated with the copper hydrate are not strictly accurate, for the ground was so thickly covered with vines that it was difficult to apply the fungicide to all parts of the leaves. But those parts which were easily reached were quite free from mildew, as were also the parts in which the liquid collected after the applications. The same is also partly true of the other plots, but on them the material was evenly applied. It may be that the hydrate of copper does not remain so evenly distributed upon foliage when it is

applied without lime ; this would largely account for the above difference.

It is impossible to give the relative merits of these fungicides after but one season's test. More trials must be made and the formulas modified before final judgment is passed. But some of the substances appear more promising than others.

Conclusions.—The hydrate of copper when applied alone is not so effective against fungi as when applied in the Bordeaux mixture. When used at the rate of $\frac{1}{8}$ pound in 22 gallons of water, it reduced injury from fungi at least 5 per cent.

The action of the borate of copper as a fungicide is not very marked when the compound is applied in an undissolved condition. When used at the rate of $\frac{1}{2}$ pound in 22 gallons of water it reduced injury from fungi about 20 per cent.

The chloride of copper as a fungicide gave better results than the Bordeaux mixture. When used at the rate of 3 ounces dissolved in 22 gallons of water it reduced injury from mildew 35 per cent. It is the most promising of the new fungicides tested.

The Bordeaux mixture reduced injury from fungi about 25 per cent.

SUMMARY.

1. *Carbonate of Copper.*

a. The action of the ammoniacal carbonate of copper as a fungicide does not appear to be lessened by the addition of Paris green or London purple. (Page 318.)

b. The ammoniacal carbonate of copper gave better results as a fungicide when used at the rate of $1\frac{1}{2}$ ounce dissolved in 1 pint of ammonia and diluted with 22 gallons of water, than when 3 ounces of the carbonate and 1 quart of ammonia were used. (Page 320.)

c. The fungicidal action of a combination of the carbonate of copper held in suspension in water, and the arsenites, is not marked. (Page 322.)

d. Combinations of the ammoniacal carbonate of copper and Paris green or London purple, or, of the carbonate of copper sus-

pended in water and these arsenites, have a caustic action upon foliage as a rule. (Page 323.)

e. Paris green renders the ammoniacal carbonate of copper more caustic than does an equal amount of London purple ; but

f. When London purple is applied in connection with carbonate of copper held in suspension in water the combination is more caustic than one in which an equal amount of Paris green is used. (Pages 322, 323.)

2. *Sulphate of Copper.*

a. The effect of the combinations of the sulphate of copper and Paris green and London purple upon fungi was unsatisfactory. (Page 325.)

b. The action of the commercial sulphate of copper upon foliage is uncertain. (Page 325.)

c. The injury done to foliage by the sulphate of copper was increased from 10 to 20 per cent. by the addition of Paris green or London purple. (Page 325.)

3. *Hydrate of Copper.*

a. When the hydrate of copper is applied alone it is not so effective against fungi as when applied in the Bordeaux mixture. (Pages 331, 332.)

b. Two applications of the hydrate reduced injury from fungi at least 5 per cent. when used at the rate of $\frac{1}{8}$ pound in 22 gallons of water. (Page 331.)

c. The hydrate of copper when applied alone did little injury to the foliage, only the peach being affected. (Page 326.)

d. The caustic properties of the hydrate is increased by the addition of Paris green. The peach was injured 35 per cent. by such a combination. (Page 327.)

4. *Borate of Copper.*

a. The borate of copper, when applied in an undissolved condition, has little fungicidal action. (Pages 331, 332.)

b. When applied at the rate of $\frac{1}{2}$ pound in 22 gallons of water, two applications reduced injury from fungi about 20 per cent. (Page 331.)

c. The action of the borate of copper upon foliage was caustic when the substance was applied in connection with Paris green, or Paris green and ammonia. The foliage of the quince,

apple, pear, and eggplant suffered least when no ammonia was used. When ammonia was used only the eggplant escaped injury. (Page 328.)

d. The borate of copper possesses no advantages over the carbonate, but its action is similar to it. (Pages 329, 332.)

5. *Chloride of Copper.*

a. The chloride of copper as a fungicide gave better results than the Bordeaux mixture. When used at the rate of 3 ounces in 22 gallons of water, two applications reduced injury from mildew 35 per cent. (Pages 331, 332.)

b. Solutions of copper chloride must be weak. One application, at the rate of 1½ ounce of the chloride in 22 gallons of water, injured the foliage of apple and peach trees. (Page 330.)

c. Paris green increases the caustic action of a solution of the chloride of copper. (Page 330.)

6. *Arsenites.*

a. Paris green, when applied in connection with the ammoniacal carbonate of ammonia, does more injury to foliage than would an equal amount of London purple. (Page 323.)

b. London purple, when applied in connection with the carbonate of copper held in suspension in water, does more injury to foliage than would an equal amount of Paris green. (Page 323.)

c. London purple and Paris green increase the caustic action of the ammoniacal carbonate of copper, of the carbonate of copper suspended in water, of the sulphate, hydrate, borate, and chloride of copper, when insecticide and fungicide were applied together.

d. The injury done to foliage by the combinations is probably due to the arsenite which is dissolved by the ammonia or the fungicide.

7. *Varieties.*

a. Some varieties of certain fruits appear to be more susceptible than others to injury from the combinations.

b. The foliage of eggplants is the only foliage which was not injured by any of the combinations.

II. EXPERIMENTS ELSEWHERE.

It may be well to state in addition to the preceding experiments what work has been done at other stations in regard to the combinations of insecticides and fungicides. Several stations* have carried on experiments in this line and the results obtained should be well known to every fruit grower. Weed of Ohio was probably the first to do practical work in this line. In Vol. iii, p. 263, of *Agricultural Science* he says: "Among the substances tested, mention may be made of copper sulphate and London purple for blight and beetles affecting potatoes; soda hyposulfite and London purple, and potassium sulfide and London purple for apple scab and codling moth, copper sulphate and London purple for plum-fruit rot and curculio, and several other similar experiments, the results of which will be duly reported in the bulletin of our station." I can find no detailed account of these experiments in the Ohio bulletins, although it appears that satisfactory results were obtained. In 1890† a combination of the ammoniacal carbonate of ammonia, 25 gallons, and Paris green, 3 ounces, was applied to the foliage of apple, cherry, grape, pear, quince, and potato. The application was made June 21, and June 27 no injury to the foliage could be seen.

Experiments with combinations of the Bordeaux mixture and arsenites have been made by Gillette.‡ The table shows the effect of applying lime with Paris green and London purple:

*Ohio Bull. Vol. ii, No. 7, Iowa Bull. No. 10, Missouri Bull. No. 13, Massachusetts (Hatch) Bull. No. 7, 11, 13, Journal of Columbia O. Hort. Society Vol. iv, Ontario, Bull. No. 10.

†Ohio, Bull. Feb. 1891.

‡See Iowa Bull. No. 10 pp. 401-420.

	Proportion of arsenite to water.			
	1 pound to 25 gal- lons.	1 pound to 50 gal- lons.	1 pound to 100 gal- lons.	1 pound to 200 gal- lons.
London purple with lime.....	14	4	1	0
London purple without lime	56	31	7	9
Paris green with lime.....	16	5	3	3
Paris green without lime	43	35	11	4

The numbers show the average percentages of injury done to the foliage of plum, apple, cherry, peach, alder, locust, poplar, grape, and squash. It will be noticed that the addition of lime reduced the injury in a marked degree.

Similar experiments were carried on with white arsenite, but entirely different results were obtained. The injury done when lime was added in applying white arsenic, was from three to twenty times greater than when lime was not used.

Since the Bordeaux mixture contains a large excess of lime, the above results may also apply when this fungicide and the arsenites are used together. In fact Gillette found that "London purple (Paris green and white arsenic have not yet been tried) can be used at least eight or ten times as strong without injury to foliage if applied in common Bordeaux mixture instead of water."

Clark, of Missouri, carried on experiments in the use of Bordeaux mixture and Paris green in combination* to determine the value of the mixture for the destruction of the codlin moth and the apple scab (*Fusicladium dendriticum*). "Two rows of Jeniton trees set to fruit were selected, one of which was sprayed twice with Paris green, and the other row was sprayed once with Paris green, and once with Paris green and the Bordeaux mixture, using two pounds of lime and four pounds of sulphate of copper instead of four pounds of lime and six pounds of sulphate of copper, to twenty-two gallons of water. The effect of the copper mixture was very marked, both upon the foliage and fruit. The leaves upon the trees thus sprayed

*See Mo. Bull. No. 13.

were larger, of better color, and remained on the trees much longer than those sprayed only with Paris green. The fruit was also larger, more fair, and less cracked." No injury to foliage is reported. It is certain that a combination of Paris green and the Bordeaux mixture can be applied with safety in the proportions ordinarily used; and the combination appears to be as effective as when the two materials are used separately.

Combinations of ammoniacal carbonate of copper and Paris green have been tried at some of the stations. Experiments made by Maynard, of Massachusetts, show that when Paris green is applied with the fungicide, even at the rate of 1 pound in 500 gallons of water, serious injury to foliage results. The combinations, however, "reduced the injury from the codling moth to 29 per cent., while where no Paris green was used the per cent. of wormy fruit was 70." The applications showed no decrease in the amount of scab present, but in every case an increase.

The effect of applying London Purple with the ammoniacal carbonate of copper, as determined by Gillette, is shown in the table†. The numbers represent percentages of injury.

	1 pound to 25 gal- lons.	1 pound to 50 gal- lons.	1 pound to 100 gal- lons.	1 pound to 200 gal- lons.	Applied.	Noted.	Days stand- ing.
Plum.....	.99	.90	.60	.50	July 15	Aug. 9...	15
Apple.....	.02	.01	0	0	Aug. 18.	Sept. 9..	22
Cherry.....	.15	.20	0	0	July 25.	Aug. 9...	15
Alder.....	.02	.01	0	0	Aug. 18.	Sept. 9..	22
					July 25.	Aug. 9...	15
Average injury.....	.34†	.39†	.20	.17			

"The results reached were not uniform but in the majority of cases the injury resulting was less than when water alone was used."

Gillette also used a combination of the sulphate of copper and London purple and his conclusion is that "the severe injury re-

* Mass. Hatch Bull. No. 11.

† Iowa Bull. No. 10.

sulting from applications of London purple in a simple sulphate of copper solution make it certain that this combination should never be used upon foliage."

E. G. LODEMAN,
Assistant in Horticulture.

NOTE.

Spraying to destroy injurious insects and fungi has now come to be a necessity in fruit growing and vegetable gardening. Much of its success depends upon the operator, however. The treatment must be timely, thorough and persistent. Above all things, *be ready*, and begin to spray the moment the first injury is seen, or even before. Study the question during the winter, and buy the materials before spring opens. Always use the finest and most forcible spray which will reach the desired height.

There are two leading insecticides,—the arsenites, and kerosene emulsion. The arsenites are Paris green and London purple. 1 lb. to 200 gallons of water is a good proportion for apples, pears, potatoes, etc. 1 lb. of Paris green to 300 or 350 gallons should be used on peaches. Never use London purple alone on peaches. For apple-worm, begin to spray just as soon as the last blossoms fall. Kerosene emulsion is the weapon to use against all kinds of plant lice out of doors. A good formula is soft soap 1 quart, kerosene 1 pint, hot water 2 quarts. Churn the materials by pumping back into the pail for several minutes. Dilute two or three times.

There are two leading fungicides,—ammoniacal carbonate of copper, and Bordeaux mixture. The former is cheaper, and much more easily made and applied. Bordeaux mixture cannot be thrown onto large trees. To make the former, use 3 oz. carbonate of copper and 1 quart 22° ammonia. This stock solution will keep, if tightly corked. When used, dilute to 25 gallons. If 26° ammonia can be obtained at your drug store, it is better to use 5 oz. carbonate, 3 pints ammonia and 50 gallons water. This is the best general fungicide. For Bordeaux mixture, use 6 lbs. sulphate copper, 4 lbs. lime, 22 gals. water. Carbonate of copper costs from 40 to 60 cts. per pound, and sulphate about 6 cents.

The only successful combination of insecticides and fungicides yet found is made of the arsenites and Bordeaux mixture. When arsenites and ammoniacal carbonate of copper are combined, the value of each material remains, but foliage is usually seriously injured.

CORNELL UNIVERSITY

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ON THE EFFECT OF A GRAIN RATION FOR
COWS AT PASTURE.

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BULLETINS OF 1891.

26. Experiences with Egg Plants.
27. The Production and Care of Farm Manures.
28. Experiments in the Forcing of Tomatoes.
29. I. Cream Raising by Dilution.
II. The Effects of a Delay in Setting on the Efficiency of Creaming.
III. Application of Dr. Babcock's Centrifugal Method to the Analysis of Milk, Skim Milk, Butter-milk and Butter.
IV. The Relation of Fibrin to the Effectual Creaming of Milk.
30. Some Preliminary Studies of the Influence of the Electric Arc Lamp upon Greenhouse Plants.
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35. Combinations of Fungicides and Insecticides, and some New Fungicides.
36. On the Effect of a Grain Ration for Cows at Pasture.

CHEMICAL DIVISION.

DETERMINATION OF FATS IN FODDERS BY DIRECT WEIGHING OF THE ETHER-EXTRACT AND BY LOSS OF WEIGHT OF THE SUBSTANCE.

The present official method for the determination of fats in fodders requires that the substance should be dried in a current of dried hydrogen, at the temperature of boiling water, for four hours to remove all the moisture; the dried substance is then extracted with ether and the extract dried to constant weight under the same conditions.

In order to meet all these requirements Prof. Caldwell described in 1888 a "New Apparatus for Drying Substances in Hydrogen and for the Extraction of the Fat." A reference to the cut and the description¹ will show that these tubes serve the double purpose of glass stoppered weighing tubes, as well as drying tubes. This apparatus was made use of in the work described in this paper in the manner indicated in the bulletin, except that the current of hydrogen was conducted in the opposite direction. This change was found to be preferable, to prevent mechanical losses by particles of the substance being carried along with the current, and also to prevent the loosening of the asbestos filter from the metallic disk supporting it.

In the same bulletin Prof. Caldwell says:—"When the extraction is completed there seems to be no reason why the amount extracted cannot be determined by weighing the dried contents of the tube as well as by weighing the substance extracted: and the drying in hydrogen is much more easily managed in the former case than in the latter; but I have not yet had time to test this variation of the method."

¹ Bulletin No. 12 Cornell University Agr. Exp. Station.

At the seventh annual convention of the Association of Official Agricultural Chemists Mr. Anderson reported on two substances that the percentage of fat by loss of weight was a little larger than by weighing the extract. This he accounted for by saying that a portion of the fat was volatilized during the extraction.

In order to obtain some idea as to the favorable or unfavorable conditions for the loss of volatile fats during the extraction process, a short thermometer, $12\frac{1}{2}$ c. m. long, was imbedded in the fodder tubes when ready for the extraction. The thermometer was of such length that it would be entirely inclosed in the extraction apparatus. Another thermometer was inserted in the flask. A number of temperature determinations were made in this way. The temperature of the substance in the extraction tubes ranged from 33° to 35° centigrade, the temperature of the contents of the flask registered $41^{\circ}+43^{\circ}$ C.

The substance before and after extraction, and the fat, were all dried at the temperature of boiling water and it would hardly seem possible that the lower and intermediate temperature of 43° would be the cause of a loss of a portion of the extract by volatilization. During the extraction the fat is in solution, and the conditions are less favorable for volatilization than in either the previous or subsequent drying at the temperature of boiling water.

A number of comparisons were made by the two methods. The tubes were dried first for the official four hours to remove the moisture, but the data obtained in this way were discordant; with some substances the agreement was close, but with others not so, there being a general tendency for higher results by the loss of weight. The work was repeated on the same substances in the following manner: instead of drying four hours, the drying was continued until duplicate weighings of the tubes agreed within one milligram. This required a variable length of time which always exceeded four hours, and in the case of gluten meal exceeded six hours. When the fats were determined by loss after drying in this way the agreement was much more satisfactory.

From the results thus obtained it appears that the first drying of four hours was not sufficient to remove all of the moisture, and the drying after the extraction removed the moisture left on the first drying; so that the loss of weight of the tubes also included

a variable amount of moisture with the ether-soluble matter. Hence the larger results by loss of weight.

In the following table the results on the same line are from the same weighed portion. The tubes were dried in hydrogen both before and after the extraction, except that tube c in samples Nos. 6, 7, and 8, and tube b of No. 11 were dried in air after the extraction.

ETHER-EXTRACT.

		By loss of weight of extraction tube.	Average.	By weighing of ether-extract.	Average.
No. 1, Brewers' grains.. ..	a	7.34		7.26	
	b	7.35	7.35	7.47	7.36
No. 2, Timothy hay.....	a	2.61		2.59	
	b	2.50	2.55	2.52	2.55
No. 3, Red clover hay	a	3.31		3.27	
	b	3.15	3.22	3.18	3.22
No. 4, Gluten meal.....	a	10.80		11.24	
	b	11.12		11.15	
	c	11.20	11.16	11.16	11.18
No. 5, Ensilage.....	a	2.22		2.19	
	b	2.28	2.25	2.32	2.25
No. 6, Cotton-seed meal.....	a	9.35		9.33	
	b	9.38		9.45	
	c	9.44	9.39	9.42	9.40
No. 7, Corn meal.....	a	4.04		3.92	
	b	3.92		4.04	
	c	3.85	3.93	3.85	3.93
No. 8, Ship stuff.....	a	4.31		4.37	
	b	4.72		4.67	
	c	4.56	4.53	4.46	4.50
No. 9, Ensilage.....	a	2.41		2.45	
	b	2.12	2.27	2.28	2.36
No. 10, Ensilage.....	a	3.20		3.20	
	b	2.73	2.97	2.73	2.97
No. 11, Ensilage.....	a	2.06		2.57	
	b	2.50	2.55	2.66	2.61
No. 12, Ensilage.. ..	a	lost		2.41	
	b	2.43		2.57	

The total average by weighing the fat was .006 per cent. higher than by the loss of weight, a difference which is insignificant.

The tubes are more convenient for drying than flasks, and no additional or expensive drying apparatus is required as for the

flasks. The drying of the tubes after the extraction can be done much more quickly and efficiently than drying the flasks, for the gas passes through the substance rather than over its surface, thereby requiring less hydrogen. More than this, the results show that the use of hydrogen in this second drying can be dispensed with.

On the whole, therefore, it is more economical as to time, apparatus and hydrogen, to determine the fats by loss of weight of the substance, while there is no loss in accuracy.

THE DETERMINATION OF ALBUMINOID NITROGEN.

In the determination of nitrogen by the Kjeldahl method directions are given for the addition of potassium sulphide to precipitate all mercury from the solution in order to prevent the formation of mercurio-ammonium compounds which are not completely decomposed by soda solution.

The determination of albuminoid nitrogen according to the present official method, requires the use of 0.7 to 0.8 grm. of copper hydroxide previous to the determination of the nitrogen by the Kjeldahl method.

The copper hydroxide is carried along in the determination, and is freely soluble in the sulphuric acid; no provision is made for its removal, and when the potassium sulphide is "added to precipitate all mercury in solution," copper sulphide is alike precipitable in the acid solution, with the mercury. The copper present is more than enough to combine with all the potassium sulphide; the result is that neither metal is completely precipitated, a large and variable portion of the mercury is left in the solution, and all the conditions are favorable for the formation of mercurio-ammonium compounds. The work given to the potassium sulphide is doubled and the object for which it is added is not attained.

In order to determine to what extent the mercury so left in the solution would affect the results, a number of determinations were started; to some the official "20 c.c. of potassium sulphide" were added, and to others a sufficient quantity of the same solution to precipitate all the copper as well as all mercury in solution. The

large amount of precipitate formed in the latter case caused so much bumping that only one determination out of six could be completed.

In order to obviate this difficulty the operation was carried on exactly as required by the official method, except that previous to distillation the acid solution was made up to 200 c.c. and divided into two equal portions. One portion was distilled with the relative official amount of potassium sulphide, and the second with enough of the same solution to make the precipitation of both mercury and copper complete. This gives a more satisfactory basis for the comparison of results, since all the conditions previous to the distillation are the same as to the degree of oxidation and the amounts of mercury and copper in solution.

The following results were obtained :

	50 c.c. K ₂ S.	30 c.c. K ₂ S.	Difference.
Ensilage No. 1.....	1.28 per cent.	1.12 per cent.	0.16 per cent.
	1.25 "	1.14 "	0.11 "
" " 2.....	.66 "	1.53 "	0.13 "
	.66 "	1.60 "	0.06 "
" " 3.....	1.36 "	1.27 "	0.09 "
	1.20 "	1.15 "	0.05 "
" " 4.....	1.52 "	1.45 "	0.07 "
	1.54 "	1.45 "	0.09 "
" " 5.....	1.18 "	1.08 "	0.10 "
	1.23 "	1.12 "	0.11 "
Average.....			.096

The constant larger proportion of nitrogen yielded in these results with the 50 c.c. of potassium sulphide must be due to the incomplete precipitation of all the mercury in solution when only 20 c.c. is added. The average difference in the ten portions amounts to nearly a tenth of one per cent.

Blank determinations with both 20 and 50 c.c. portions of potassium sulphide gave no nitrogen. A difference of a tenth of one per cent. when multiplied by the protein factor would make a difference of over six-tenths per cent. of protein, which is too great to be overlooked.

Some change must therefore be made in combining Stutzer's and Kjeldahl's methods. The following proportions of substance and solutions have given me satisfactory results. Take 0.7 grm. of substance instead of 1 grm., a quantity of copper hydroxide and glycerine solution equivalent to .5 to .6 grms. of the hydrox-

ide instead of .7 to .8, and finally 30 c.c. of potassium sulphide instead of 20 c.c. Trials of these proportions on the committee sample of corn meal gave 1.56 per cent. and 1.55 per cent. of albuminoid nitrogen; with the old proportions, and all of the copper and mercury likewise precipitated, 1.56 per cent. of albuminoid nitrogen.¹

In the determination of *nitrates* by the official method, 2 grms of zinc dust are used; but the previous addition of 2 grms. of salicylic acid converts the zinc into an insoluble form at the close of the digestion. This is shown to be true by the following results of the analysis of pure potassium nitrate, when the solution was divided as in the case of the determination of albuminoid nitrogen:

	20 c. c. K ₂ O.	40 c. c. K ₂ S.
1. Nitrogen.....	14.02 per cent.	14.02 per cent.
2. ".....	13.98 " "	13.98 " "

If in the above tests the salicylic acid is omitted the results obtained are not uniform, and fall short of the actual amount of nitrogen present. This is due to the presence of the zinc in solution, which causes the same trouble as the copper. Any other metal precipitable by potassium sulphide would be equally liable to produce the same effect, as all of the conditions would be equally favorable for the formation of mercurio-ammonium compounds.

DRYING SAMPLES OF FRESH MANURES.

In the analysis of farm manures, the most serious difficulty met with in the whole process, is the drying of the samples. If the sample is allowed to dry in the air, there is a possibility of a loss of nitrogen in the form of ammonia, and such drying is always accompanied by the formation of disagreeable volatile products. The sprinkling of the sample with a weak solution of oxalic acid has been proposed; this answers very well, but it is open to the objections of retarding the drying at first by increasing the percentage of water.

The drying can be carried on by artificial heat without loss of ammonia in the following simple manner:

¹ These changes as given above have been adopted in the official method.

The sampling bottle in which the manure is received is provided with a two-hole rubber stopper. Through one of these holes a glass tube with six or eight holes blown out through its walls is carried to the bottom of the bottle ; another tube passes first through the other hole of the stopper and is carried from this bottle through an upright condenser, and then nearly to the surface of a small quantity of standard acid in an Erlenmeyer flask. Hot air is aspirated through the bottle containing the manure and thence through the condenser and Erlenmeyer flask, where all escaping ammonia is caught, and can be determined by titration.

This method has been applied to the drying of samples of horse and hog manure, with satisfactory results.

THE DETERMINATION OF NITROGEN IN SOILS.

For the determination of the total nitrogen in soils, the modified Kjeldahl method has been proposed so as to include the nitrous and nitric nitrogen ; but this modification introduces many difficulties. In dealing with soil a large quantity of substance must be taken for the determination, and the addition of zinc dust and salicylic acid farther increases this bulk ; the zinc dust cannot be intimately mixed with the soil without much labor; and the amount of nitrogen in the form of nitrates and nitrites is too small to be determined in this manner.

In the case of fifteen samples of soil analyzed in this laboratory, only one yielded as much as 0.001 per cent. of nitrous and nitric nitrogen ; this is too small a quantity to be determined by titration and it is moreover much within the limits of error in the determination of total nitrogen, as the following results on some of the same samples of soil show :

Soil sample.	Nitrogen per cent.	Soil sample.	Nitrogen per cent.
No. 1.....	.070	No. 4.....	.0795
"	.066	"	.076
No. 2.....	.057	No. 5.....	.052
"	.053	"	.055
No. 3.....	.068	No. 7.....	.051
"	.063	"	.053

Furthermore, the nitrogen in the reagents used in the modified Kjeldahl method is usually greater in amount than that from the nitrites and nitrates in soil. Reagents can be prepared for the usual Kjeldahl method that yield no nitrogen in blanks, while the same is not true of the modified method.

In the modified Kjeldahl method the breakage and proportion of loss from bumping is greater than in the direct method.

In view of the fact that the nitrates and nitrites are separately determined by more delicate methods, and that nothing is gained by the modified Kjeldahl method, while many difficulties are introduced by its use, the direct method is much to be preferred, with a separate determination of the nitrite and nitrate.

MISCELLANEOUS ANALYSES.

Name of sample.	In the original substance.						
	Moist-ure.	Pure ash.	Ether-extr'ct.	Crude pro-tein.	Crude fibre.	N-free extr'ct.	Total nitro-gen.
Gluten meal.....	8.50	1.03	11.20	19.35	5.20	54.72	
Brewers' grain.....	10.65	4.27	10.65	20.00	11.52	46.21	3.20
Cotton-seed meal.....	7.66	7.46	9.40		44.74	28.57	7.16
Corn meal.....	12.07	1.07	3.98	9.74	2.54	70.57	1.56
Ship stuff.....	11.84	5.20	4.51	17.74	8.25	52.46	2.84
Anthers of corn.....	9.15	5.70	2.49	17.19	17.45	48.02	2.75
Pollen of corn.....	10.25		1.16	21.12	5.71	59.13	

SAMPLING MILK.

A large amount of literature has appeared from time to time upon the subject of sampling of milk, a review of which would lead one to believe that no two samples drawn from the same can, would, upon analysis, show the same composition, even with the special sampling tubes and other mechanical devices that have been proposed. During the months of July and August an opportunity was offered for a study of this question in connection with the experiment upon the effect of a grain ration for cows at pasture. Individual samples of milk were taken from the night and morning milkings of a herd of sixteen cows. Also the milk of the whole herd was divided into two lots, each lot representing

the milk of a whole day, of eight cows, and then sampled. The results of the analyses are given in the following table; the numbers 13, 7, etc., are those of the samples of milk from the corresponding cows. The sample designated as "mixture" is a sample of the mixed milk of the eight cows in each lot.

JULY 24, 1891.

<i>Lot I.</i>				<i>Lot II.</i>			
Sample No.	13	4.90	per cent. fat	Sample No.	8	4.80	per cent. fat
" "	7	4.00	" " "	" "	1	4.50	" " "
" "	2	3.50	" " "	" "	12	5.00	" " "
" "	15	4.50	" " "	" "	3	3.80	" " "
" "	9	4.90	" " "	" "	10	4.40	" " "
" "	5	4.50	" " "	" "	16	5.50	" " "
" "	6	3.80	" " "	" "	11	5.20	" " "
" "	14	3.10	" " "	" "	4	4.60	" " "
Average.....4.17				Average.....4.50			
Mixture.....4.10				Mixture.....4.50			

AUG. 22.

<i>Lot I.</i>				<i>Lot II.</i>			
Sample No.	13	4.95	per cent. fat	Sample No.	8	5.25	per cent. fat
" "	7	3.75	" " "	" "	1	3.40	" " "
" "	2	3.70	" " "	" "	12	5.00	" " "
" "	15	4.80	" " "	" "	3	3.10	" " "
" "	9	5.60	" " "	" "	10	4.60	" " "
" "	5	4.65	" " "	" "	16	5.00	" " "
" "	6	4.85	" " "	" "	11	6.20	" " "
" "	14	4.80	" " "	" "	4	4.75	" " "
Average.....4.31				Average.....4.63			
Mixture.....4.20				Mixture.....4.61			

From these results it would appear that the percentages of fat for each individual cow must represent, with a fair degree of accuracy, the real amount of fat present: for any slight error in the sampling of the mixed milk of each lot, or of the night or morning's milk of any of the individual cows would have made itself apparent in the results. These samples were taken by simply mixing the milk with a long handled dipper and the results show that for the quantity of milk sampled (180 lbs.), no sampling tube or other mechanical device was necessary. All the samples were brought to the laboratory in numbered bottles, and the analyst had no other information in regard to them till after all the analyses had been made.

HARRY SNYDER.

BOTANICAL DIVISION.

SOME NOTEWORTHY WEEDS.

Within a comparatively recent period a number of weeds have made their appearance in the state of New York, especially in the central counties, which show a marked tendency to become troublesome, while others of an earlier introduction appear to be increasingly aggressive. Three weeds belonging to the one or the other of these classes are here noticed.

1. GOLDEN HAWKWEED. (*Hieracium aurantiacum*). • This plant is a foot or more in height and readily recognized by its very showy flowers (or rather flower heads) of a deep orange or flame color, appearing in early summer. It is a perennial, and increases by runners as well as by seeds. It is not mentioned in any of the earlier editions of Gray's Manual, but in the latest (1890) edition is spoken of as occurring in fields and by roadsides from New England to New York. It seems to have been for some time established near Oswego where it has taken possession of whole fields. Within the last few years it has been reported from a number of different places in the central part of the state. The plant shows all the qualities of a persistent and aggressive weed, except that it does not increase with very great rapidity. Its habit is such that it ought to be promptly exterminated whenever it makes its appearance. It is of European origin, and was probably first introduced into the new world as an ornamental plant; its habits, however, render it quite too dangerous to use for this purpose. Fig. 1.

2. FIELD CHAMOMILE. (*Anthemis arvensis*.) This plant is also a native of Europe, and although not of recent introduction, being spoken of by Darlington as quite common about New York City more than forty years ago, is nevertheless recorded as rare in the last edition of the Manual. It appears, however, to be rapidly increasing in central New York, showing a very decided



FIG. 1.—Golden Hawkweed (*Hieracium aurantiacum*). Drawn from nature by W. W. Rowlee.

tendency to become abundant and troublesome. It resembles the mayweed very closely in appearance, but the flowers are larger, the foliage of a deeper green color, and the odor more pleasant and agreeable. It is generally considered an annual, but the seeds of the current season become well established plants before the advent of winter. It appears like a species which through varietal change has produced new forms possessing greatly increased weed-like characteristics.

3. BEARD-TONGUE. (*Pentstemon laevigatus*, var. *Digitalis*.) This plant is a native from Pennsylvania west-ward, but has found its way into central New York where it promises to become a more or less troublesome weed. According to Mr. Rowlee it has taken possession of a field in the eastern part of Tompkins County, and seems to be increasing and spreading with a considerable degree of rapidity. The plant is four to five feet high, showy in appearance, with numerous white, tubular flowers, an inch or more in length, borne in loose clusters at the top of the stem. An effort should be made to prevent this plant from securing a foot hold in other localities. It belongs to a family which furnishes a number of well known weeds among which the common mullein, the moth mullein, butter and eggs, and the speedwells, those pests of the lawn, may be mentioned. Fig. 2.

VARIATION IN ROOT PRESSURE IN DIFFERENT SPECIES.

By root pressure is meant the power of the roots of certain plants of forcing water, taken up by absorption from the soil, upwards into the stem. A familiar illustration of this power is seen in the grapevine when cut off in the spring, the roots forcing water upwards into the stem, causing it to run over, or bleed, at the cut surface. Root pressure, as here defined, appears to be wholly wanting in certain species, and in the same species occurs at different periods.



FIG. 2.—Beard-tongue (*Pentstemon laevigatus* var. *digitalis*). Drawn from nature by W. W. Rowlee.

The observations as here recorded are intended to show the variation in the force of root pressure in different species of green house plants grown in pots and subjected to the same conditions of heat, light and moisture. The plants were prepared for the experiment by cutting off the stems three inches above the ground and attaching a glass tube to the stump by means of a piece of rubber tubing, which was strongly wired at both ends as shown in the figure. The height to which the water rose in the glass tube was supposed to show the relative force of root pressure in the several species. The plants were all strong and healthy and apparently in a vigorous condition of growth.



FIG. 3.—Plant prepared to show root pressure.

In the following table the results of the experiment are shown, fractions being omitted.

TABLE I.

Kinds of plants.	Total rise of water in the tube in inches.	Average rise of water per 24 hours in inches.
Balsam a.....	97	11
" b.....	49	5
" c.....	61	5
Begonia a.....	65	3
" b.....	57	2
Eucalyptus	1.5	
Coleus.	15	1
Geranium.	1.5	

The length of time in days during which the water continued to rise in the several tubes may be determined approximately by dividing the figures of the second column by those of the third.

In the following table the variation in root pressure is reduced to equivalent values, the lowest being taken as the unit. Fractions are omitted.

TABLE II.

Kind of plant.	Units of root pressure.
Balsam a	65
" b.....	33
" c	40
Begonia a.....	43
" b.....	38
Eucalyptus.....	1
Coleus.....	10
Geranium.....	1

Summary.—The results show a marked variation in the force of root pressure in different species, and a considerable variation in different individuals of the same species.

A. N. PRENTISS.

AGRICULTURAL DIVISION.

DEHORNING.

We have received so many inquiries in regard to this practice that it has seemed worth while that we should give a brief outline of our experience, in this bulletin. We have made it a practice, for the past six or seven years, to dehorn our cows as soon as they come into the dairy, and at the present time there is no animal having horns on the farm. While for the most part, the horns have been removed by students and others who have never even seen the operation performed, we have, as yet, to meet the first case where there has been any ill effect following the operation. The last time the operation was performed, was on Nov. 5, 1891, at which time, among others, five cows in milk were dehorned. Three of these were heifers under two years old, two were mature cows that had been purchased in the neighborhood; all were comparatively fresh in milk. One, the first one in the table, had only been milked six days. In table I below, is shown the daily milk yield of the five dehorned cows on the day of the operation and for the five days preceding and following. In table II is shown the daily milk yield of seven cows, not dehorned, for the same days. These cows had been in milk approximately the same length of time as those dehorned.

TABLE I—DAILY MILK YIELD—FIVE DEHORND COWS.

	Days before dehorning.					Nov 5, 1891. Dehorn- ed. lbs.	Days after dehorning.				
	5th. lbs.	4th. lbs.	3rd. lbs.	2nd. lbs.	1st. lbs.		1st. lbs.	2nd. lbs.	3rd. lbs.	4th. lbs.	5th. lbs.
Carrie				7.25	8.50	8.75	8	9	8.25	8.75	8.50
Daisy	8.50	7.50	8.50	7.75	7.50	8.25	7.75	7.50	7.75	7.50	7.50
Ida	14.50	12.50	12	9.25	13	13	12.25	13	13	12.75	13.25
Pandora	27.25	26.50	24	26.75	27.50	24.50	18.50	25.75	25.75	25	23.75
Roxy	26.50	27.50	27.50	27.50	27	25.25	25.25	28	27.25	27.75	27.75

TABLE II—DAILY MILK YIELD—SEVEN COWS NOT DEHORND.

	5th. lbs.	4th. lbs.	3rd. lbs.	2nd. lbs.	1st. lbs.	Nov. 5, 1891.	1st. lbs.	2nd. lbs.	3rd. lbs.	4th. lbs.	5th. lbs.
Belva.....	40.75	38.25	42.50	37.50	40.75	34	36.50	41.50	39.25	38	37.50
Bertha.....	17.25	16	16.75	15.75	16	17	15.50	16	16	16.75	15.75
Freddie.....	42	42	45	41.50	44.50	43	43.25	43	43	40.50	40.25
Glista.....	20.75	20.25	21	23.25	22.25	21.50	23.75	22.25	22.50	22.25	20.75
Pearl.....	27.75	28	25.75	24	27.75	29.25	27	28	29.25	26.75	28.25
Ruby.....	19	19.75	20.25	21	22.75	24	22.50	24	22.50	23	22.75
Shadow.....	36.50	33.50	33	34.50	24.50	29	29	30.25	31	31.75	30

A glance at tables I and II shows that the cows dehorned were very little affected by the operation, with the exception of the cow, Pandora. It will be seen that she fell off three pounds upon the day on which she was dehorned and six pounds more on the following day, after which she nearly regained her normal flow. The variations in the case of the other cows were extremely trivial, and it will be seen by referring to table II that some of the cows not dehorned varied quite as much, and that, too, on the same days ; for instance, Belva fell off six and three-quarters pounds on the same day on which the others were dehorned, and Shadow fell off ten pounds on the day preceding. In the following table we have shown the losses immediately following the operation with each individual, and also the extreme variation in the whole period of five days before and five days following, and for purposes of comparison, have included the variations on these days for the cows that were not dehorned.

TABLE III.

	Av. daily yield for 5 days preced- ing. Lbs.	Gain + or loss — on day of opera- tion. Lbs.	Gain + or loss — on day follow- ing opera- tion. Lbs.	Total gain or loss in 2 days. Lbs.	Variation between lar- gest and smallest y'd in 11 days. Lbs.
<i>Cows dehorned :</i>					
Carrie.....	8.00	+ .75	— .75	+ .00	1.75
Daisy.....	8.00	+ .25	— .50	— .25	1.00
Ida.....	12.25	+ .75	— .75	+ .00	5.25
Pandora.....	26.50	— 2.00	— 6.00	— 8.00	9.00
Roxy.....	27.25	— 2.00	+ .00	— 2.00	2.75
Average.....		— .45	— 1.60	— 2.05	3.95
<i>Cows not dehorned :</i>					
Belva.....	40.00	— 6.00	+ 2.50	— 3.50	8.50
Bertha.....	16.25	+ .75	— 1.50	— .75	1.75
Freddie.....	43.00	+ .00	+ .25	+ .25	4.25
Glista.....	21.50	+ .00	+ 2.25	+ 2.25	3.50
Pearl.....	26.75	+ 2.50	— 2.25	+ .25	5.25
Ruby.....	20.50	+ 3.50	— 1.50	+ 2.00	5.00
Shadow.....	32.50	— 3.50	+ .00	— 3.50	12.00
Average.....		— .39	— .04	— .43	5.75

It will be seen that in the case of the dehorned cows, there was an average loss of a little more than two pounds per cow for the day of the operation and the day following, as compared with the average yield for the five days preceding. On the other hand, it will be seen that the seven cows that were not dehorned gave on these two days an average of forty-three hundredths of a pound of milk less than the average for the five days preceding ; so that not all of the two pounds could well be attributed to the operation of dehorning. When we come to consider the extreme variation in the yield, as shown in the last column of table III, it will be seen that the average variation of the five dehorned cows was a little less than four pounds in the whole period of eleven days, while the average variation of the seven cows, not dehorned, in the same period was nearly six pounds. This was undoubtedly due to the fact that the average milk yield of the seven cows not dehorned was considerably greater than of the five dehorned cows ; but it shows that the operation of dehorning did not cause at least any greater daily variation.

So much for the immediate effects of dehorning, now as to the time required for recuperation. We have shown in table IV the gain or loss in the milk yield for the five days following the operation as compared with the five days preceding, and here we find that there was an average daily loss of a little less than one-half a pound for the five cows dehorned, but in the same time the seven cows that were not dehorned, gave seven hundredths of a pound per day less in the last five days. It would seem then, studying the milk yield in all its relations, that the loss in milk yield, when cows in milk are dehorned, is insignificant.

TABLE IV.

	Average milk yield for 5 days before operation. Lbs.	Average milk yield for 5 days following operation. Lbs.	Gain + or loss — per day. Lbs.
Cows dehorned.			
Carrie.....	8.00	8.50	+ .50
Daisy.....	8.00	7.50	— .50
Ida.....	12.25	12.75	+ .50
Pandora.....	26.50	23.75	—2.75
Roxy.....	27.25	27.25	+ .00
Average.....			— .45
Cows not dehorned.			
Belva.....	40.00	38.50	—1.50
Bertha.....	16.25	16.00	— .25
Freddie.....	43.00	42.00	—1.00
Glista.....	21.50	22.25	+ .75
Pearl.....	26.75	27.75	+1.00
Ruby.....	20.50	23.00	+2.50
Shadow.....	32.50	30.50	—2.00
Average.....			— .07

The only requisites for successfully performing the operation are that the animal's head should be securely fastened and the operator possessed of courage, and a sharp saw. We have ordinarily used what is known by carpenters as a "cut off" saw; that is, a small, flexible saw, with rather fine teeth; others have preferred to use a stiff back saw. The horns should be removed from the head so as to take with them just a few hairs, all the way around. It is usually of advantage to clip off some of the hairs about the base of the horn, with a pair of shears, and before beginning, the operator should examine the horn and get his bearings, so that when once the operation is begun no stop need be made until the horn comes off; ordinarily but very little blood is lost in the operation; some animals, however, will bleed considerably and very rarely it is necessary to bind a rag smeared with

pine tar over the stump to stop the bleeding. Animals under three years old that are in good flesh and thrifty growing condition are more apt to bleed freely. It is not necessary that any application be made to the stump, but we have thought it of advantage to apply a little carbolated vaseline; this is chiefly of benefit in warm weather in keeping away flies. Usually the wound heals up without suppurating but in about one case in ten, some pus will form. We have found it of advantage in such cases to bind on a rag smeared with pine tar as before described.

Since the operation referred to above was performed Mr. S. Alfred Seely, of Spencer, N. Y., sent us for trial a pair of patent dehorning clippers, invented by Dr. H. W. Leavitt, of Hammond, Piatt Co., Ill. We have used these upon the cattle of our neighbors sufficiently to show us that they are far superior to any method we have yet seen devised. They act upon the principle of the pruning shears and remove the horns more easily than the saw and with apparently considerably less pain to the animal.

A NEW MATERIAL FOR PRESERVING EGGS.

In the summer of 1890 we received from Messrs. A. E. Richter & Co., of Fond du Lac, Wis., through Messrs. Munn & Co., of New York, a package of material with a request that it should be tested as a material in which to pack eggs for preservation till winter.

The material was a brick red mineral, extremely finely ground, and a chemical analysis showed that it was principally composed of silicates of iron, lime and aluminum, the reddish color being due to the iron.

Sept. 9th, there was purchased from a dealer in the city, some eggs, guaranteed by the expert in the employ of the firm to be fresh. Part of these eggs were packed in a barrel with the Richter mineral, part in a nail keg in fine salt, and still another part in a stone crock in a solution of lime water and brine. All were placed in a dry, cool room where the temperature varied from fifty-five to sixty-five degrees.

Jan. 21, 1891, the eggs were unpacked; there were taken out the following numbers:

From the Richter mineral.....15 dozen and 11.

From the salt9 dozen and 9.

From the solution of lime water and brine, 3 dozen and 6.

They were examined carefully with a candle by the same expert from whom the eggs were purchased and the following numbers were thrown out as absolutely bad from each lot :

From the Richter mineral.....9 eggs or 4.7 per cent.

“ “ salt.....5 “ “ 4.3 “

“ “ solution of lime water and brine 2 “ “ 4.8 “

It will be seen that no better results were obtained from the use of this mineral than from the use of salt, or lime water and brine. To further test the matter, some eggs known to be not more than two days old were purchased, and with the eggs preserved in the different ways, and all marked simply with numbers, were sent to eight different ladies in the neighborhood, with the request that a cooking test be made of each of the lots, and their opinion given as to their comparative value. All, without exception, pronounced the preserved eggs much inferior to the fresh, and most of the ladies reported that, of the preserved eggs, those kept in salt were somewhat better than those preserved in the Richter mineral.

It would seem that this new material for preserving eggs, offers no advantage over the use of fine salt.

I. P. ROBERTS.

ENTOMOLOGICAL DIVISION.

THE HORN FLY.

Hæmatobia serrata.

Order DIPTERA ; family MUSCIDÆ.

A small black fly, one half the size of the common house fly, attacking cattle in the field, and oftentimes resting in large numbers around the base of the horns.

This recently imported European cattle pest first made its appearance in considerable numbers in this country near Philadelphia during the summer of 1887. Since that time it has spread quite rapidly in all directions and now the farmers of at least nine states (Pennsylvania, Delaware, New Jersey, Maryland, Virginia, West Virginia, New York, Kentucky and Ohio) recognize it as a troublesome pest among their cattle. During the past summer the flies have appeared in the southern, the central, and the extreme western portions of our State ; and inquiries regarding the new pest have been so numerous that it seems advisable to here briefly discuss what is known of its habits, its life history, and the remedies which have been recommended.

The insect has been investigated by Dr. Riley and Mr. Howard of the Department of Agriculture at Washington, and by Prof. J. B. Smith of the New Jersey Experiment Station ; our information is condensed from their published reports.*

The insect appears to be a native of southern Europe, where it has not however been reported as a serious pest. It was probably brought to this country with imported European cattle about 1886. The fly, which has been known in Europe since 1830, is of a dark greyish-black color and belongs to the same order of insects as our common house fly, which it resembles in general

* Riley and Howard: Annual Rept. of U. S. Entomologist, 1889, p. 345-348 ; l.c. 1890. p. 246-249 ; Insect Life, Vol. 2, p. 93-104 ; l.c. Vol. 3, p. 42.

Smith: Bulletin No. 62, New Jersey Experiment Station, Nov. 1889, 40 pages.

appearance. It is about one sixth of an inch in length and its whole body is quite densely clothed with stiff blackish hairs. The head is almost entirely taken up by the eyes, which are of a dark reddish-brown color. The proboscis, the instrument with which the biting is done, is conspicuous and when the fly is at rest it projects straight forward from the head ; on each side of the proboscis is an unusually long palpus densely clothed with short stiff hairs. The abdomen is rather small, almost as broad as long and flattened above.

In localities where the pest has become established, the flies first appear in May. They increase in numbers very fast until in June and July they appear in swarms and torment the cattle to such an extent that in many cases the animals lose condition and the yield of milk is lessened from one-third to one half. As fall approaches the flies become less and less numerous and finally disappear with the first cold and frosty weather.

The flies instinctively seek those portions of the body which are not easily reached by the head or the tail of the animal, as the back, the flanks, beneath the belly, and on the udder. A fly alights on the animal, quickly works its way, with wings still expanded and ready for instant flight, among the hairs, and soon the proboscis has punctured the skin and the blood of the animal is being pumped into the body of the fly. During the early part of the summer especially, the flies congregate in large numbers about the base of the horns. This peculiar habit suggested the popular name, the Horn Fly. The flies do not feed upon the horn or the skin about its base as many suppose, but they simply rest there with the wings folded over the back. In some cases large sores are found on the body of an animal in its efforts to rid itself of the flies by continued rubbing against objects and by licking the spot where bitten. The flies usually confine their attacks to the cattle in the field but sometimes they follow the animals indoors and torment them in the stables.

The early stages of the Horn Fly are not passed on the cattle as some suppose, but in and beneath the piles of freshly dropped dung in the field. The eggs, which are only .05 of an inch in length and .015 of an inch in diameter are of a reddish brown color and are laid during the daytime on the surface of dung which has just been dropped. In shape the

eggs are elongate oval slightly curved with one side flattened. Within twenty-four hours a narrow spoon-shaped strip splits off from the flattened side of the egg, and a white footless grub emerges and descends for a short distance into the dung upon which it feeds. The grub or larva grows rapidly and in about five days it is full grown and measures .35 of an inch in length. It is of a dirty white color, nearly smooth, and tapers considerably toward the head which is cleft at the tip. When full grown the larva descends for a short distance into the ground below the dung. It there shrinks nearly one half in length, the skin hardens, becomes reddish-brown in color, and a short elliptical puparium results. While in this state which lasts about six days, the insect remains inactive. A fully developed fly emerges from the puparium and soon joins its comrades on the bodies of the cattle. Thus the whole life cycle of the pest from the laying of the egg to the appearance of the fly occupies a period of only about two weeks. This rapid multiplication of the species accounts for its appearance in such swarms and renders it possible for seven or eight generations of the flies to appear during the year. The winter is probably passed in the pupa state in the ground beneath the dung.

Remedies :—Two classes of remedies are practicable ; preventive, to prevent injury to the cattle by keeping off the fly ; and destructive, by destroying the insect in its larval or adult condition. The fly may be kept away from the cattle for several days by the application of almost any greasy substance to the parts more liable to attack. Fish oil, to which a little carbolic acid has been added as a healing agent, is the most highly recommended ; common axle-grease, tallow, kerosene emulsion, or sheep-dip may be used to good advantage. The substance may be applied with a sponge or as a spray. One thorough application is often sufficient, but as its repelling power usually lasts only five or six days, it may be necessary to repeat the application.

Among the destructive agents for the fly, tobacco powder is considered the best. It should be dusted on those parts where the flies most usually congregate, and it is certain death to those that come in contact with it. The larvae may be destroyed by scattering a little lime or plaster on the fresher droppings in

the field. This should be done in the early part of the season as every larva killed then represents the death of many flies later. In many cases this is a very practical remedy for the lime or plaster is cheap and in almost every field there are some spots where the cattle preferably congregate during the heat of the day and the droppings will be more or less together and easy to treat.

MARK VERNON SLINGERLAND.

HORTICULTURAL DIVISION.

PHYSALIS,* OR HUSK TOMATO.

Under the name of Husk Tomato, Strawberry Tomato, Winter Cherry, and Ground Cherry, species of *physalis* have come into prominent notice during the last few years. The genus *physalis* is somewhat allied to the tomatoes and red peppers, and like most other groups of the family it is puzzling to botanists. There are a number of native species of *physalis*, one or two of which are well known in some parts of the country as ground cherry, and the fruits of which are esteemed for preserves. In fact, one of these native plants (*Physalis pubescens*) is the same species as the commonest husk tomato of the gardens, although the cultivated form probably came first from some tropical or sub-tropical country. This species is very widely distributed. There has been no recent attempt to distinguish the species and varieties of our cultivated *physalis*, and knowledge of them is greatly confused. We have grown seven species,† only three of which need be discussed here, as they are the only ones which appear to have been introduced into cultivation as fruit-bearing plants. These three are as follows :

1. *PHYSALIS PUBESCENS*. Fig. 4. This is the common Strawberry Tomato of seedsmen (the Erdbeer tomato of the Germans), the Dwarf Cape Gooseberry, Golden Husk Tomato, and the Improved Ground Cherry (of Childs). It is a low plant, trailing flatly upon the ground, or sometimes ascending to the height of a foot. The leaves are rather thin and nearly smooth, more or less regularly and prominently notched with blunt teeth. Flowers small ($\frac{3}{8}$ in. or less long), bell-shaped, the limb or border erect and whitish-yellow, the throat marked with five large brown

*Pronounced *Fiss'-a-lis*.

†*Physalis pubescens*, Linn. *P. Peruviana*, Linn. *P. capsicifolia*, Dunal. *P. Alkekengi*, Linn. *P. viscosa*, Linn., from Paraguay (collected by Dr. Thomas Morong). *P. angulata*, Linn., and *P. obscura*, Michx., from our southern states.



FIG. 4.—Common Strawberry Tomato (*Physalis pubescens*, Linn.). Detached fruits full size.

spots; anthers yellow. The husk is smooth or nearly so, thin and paper-like, prominently 5-angled and somewhat larger than the small, yellow, sweetish and not glutinous fruit. Fig. 4 is an excellent portrait of this species. The detached fruits are natural size, although the fruit is sometimes larger than these. The plant is very prolific, and the fruits are considerably earlier than in the other species. When ripe, the fruits fall, and if the season is ordinarily dry they will often keep in good condition upon the ground for three or four weeks. The fruits will keep nearly all winter if put away in the husks in a dry chamber. They are sweet and pleasant, with a little acid, and they are considerably used for preserves, and sometimes for sauce. The plant is worthy a place in every home garden. It is grown more or less by small gardeners near the large cities, and the fruits are often seen in the winter markets. The chief objection to the plant is its prostrate habit of growth, which demands a large amount of ground for its cultivation. In good soil it will spread four feet in all directions if not headed in, but as we ordinarily grow it, the plants are set in rows three or four feet apart and two or three feet apart in the row. We have made repeated attempts to hybridize this species with others, and *vice versa*, but always without success.

This *physalis* has been long in cultivation. It was figured by Dillenius in 1774, in his account of the plants growing in Dr. Sherard's garden at Eltham, England*. In 1781-6 it was figured by Jacquin†, and by him called *Physalis Barbadosis*, from the island of Barbadoes, whence it was supposed to have come into cultivation. In 1807, Martyn‡ described it under the name of Barbadoes Winter Cherry or *Physalis Barbadosis*, and says that it is a native of Barbadoes. None of these authors say anything about its culinary uses. Dunal||, in 1852, described it as var. *Barbadosis* of *Physalis hirsuta*, but later botanists§ unite Dunal's *P. hirsuta* with Linnæus' *P. pubescens*, of which this husk tomato is but a cultivated form.

2. *PHYSALIS PERUVIANA*. Fig. 5. I have grown this under

* Hort. Eltham. t. 9, fig. 9.

† Icones Pl. Rar. i. 5, t. 39.

‡ Martyn's Miller's Dict. 1807, *Physalis* No. 14.

|| D. C. Prodr. xiii (i). 446.

§ See A. Gray, Syn. Fl. ii. part 1. 234.

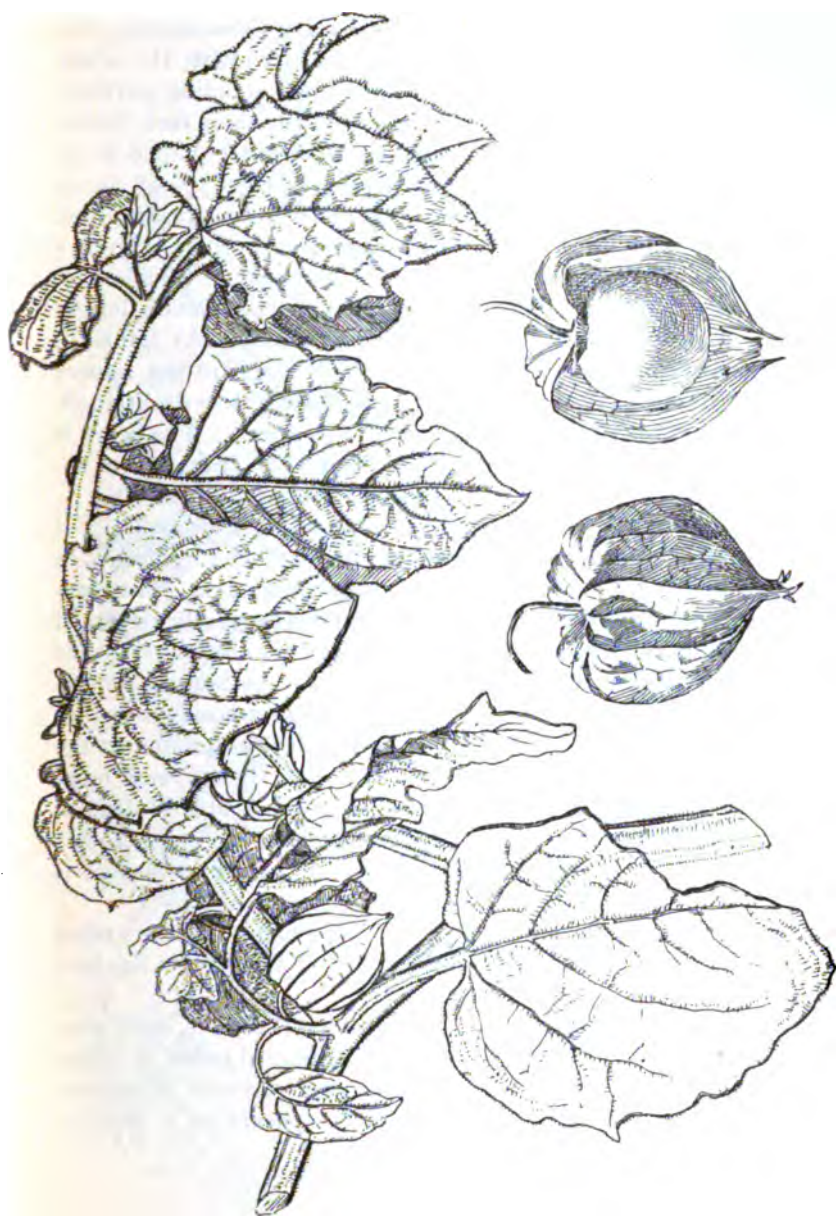


FIG. 5.—*Peruvian Husk Tomato (Physalis Peruviana, Linn.)*. Fruits natural size.

the names Cape Gooseberry (not Dwarf Cape Gooseberry), *Physalis Peruviana*, and *P. pubescens*. As compared with the above species, it is a much stronger grower, the plant standing partially erect and attaining a height of one and a half to three feet; leaves thicker, less regularly toothed, more pointed, heart-shaped at the base, and very pubescent or fuzzy; flowers larger ($\frac{1}{2}$ or $\frac{3}{8}$ in. long), open-bell-shaped, the limb or border widely spreading and light yellow, the interior or throat blotched and veined with five purple spots, the anthers blue-purple. The husk is thicker and larger than in the last, somewhat hairy, and has a much longer point. This species is too late for our climate. At Lansing, Michigan, during two or three years, the flowers did not appear until the middle of August, and very few ripe fruits were obtained. Here at Ithaca perhaps a fourth of the crop ripens. The berry is yellow, not glutinous, and much like that of *P. pubescens* in appearance, but it seems to be less sweet than that species.

This plant has been cultivated for two centuries, probably. It was described and figured by Morison in 1715* in England. In 1725 Feuillée† gave a description of its cultivation in Peru, saying that it was then cultivated with care and was greatly esteemed as a preserve. The particular form of the species cultivated in our gardens is that which was described and figured by Sims in 1807 as *Physalis edulis*, the "edible physalis."‡ Sims' account says that "this plant is a native of Peru and Chili, but is cultivated at the Cape of Good Hope, in some parts of the East Indies, and more especially at the English settlement of New South Wales, at which latter place it is known by the name of the Cape Gooseberry, and is the chief fruit the colonists at present possess; is eaten raw, or made into pies, puddings, or preserves."

This plant is rarely sold by American seedsmen. I have grown it mostly from French seeds. I once had it from New Zealand under the name of Cape Gooseberry.

3. *PHYSALIS CAPSICIFOLIA*, "capsicum leaved" or "pepper-leaved physalis." Fig. 6. From a botanical point of view, this is one of the most interesting species of physalis in cultivation. It is exceedingly variable, and it appears as if distinct

* Pl. Oxon. 3, 526, sect. 13, t. 3, fig. 17.

† Journ. Obs. Phys. Math. et Bot. iii. 5, t. 1.

‡ Bot. Mag. t. 1068.



FIG. 6.—Pepper-leaved *Physalis* (*Physalis capsicifolia*, Dunal). Fruits full size.

varieties can be readily bred from it. We have grown it under two or three names. It is usually called, though erroneously, *Physalis edulis*. This name is misleading, for the fruit is really scarcely edible because of its very pronounced mawkish flavor. The fruit is far the largest and handsomest of any *physalis* which I have grown, and it is not improbable that we may be able to obtain a desirable variety from it. The plant is exceedingly productive, and adapts itself to almost any soil or condition. It grows erect to a height of three or four feet, bearing smooth branches and leaves. The leaves are thin, ovate or lance-ovate and variously toothed or notched. The flowers are large and open ($\frac{3}{4}$ in. or more across), the border bright yellow and the throat bearing five black-brown spots; anthers purplish. The husk is entirely filled by the large round sticky berry, and is sometimes torn open by it.

This plant is supposed to be native to South America or the West Indies. It was early grown in gardens, perhaps because of its supposed medicinal properties. Dr. Sherard obtained it in Holland in the last century and grew it in his garden at Eltham, England, and Dillenius figured it in 1774.* Martyn† described it in 1807, but says nothing about its uses. An interesting feature of the plant is its great variability. Dillenius figured the leaves as nearly entire, and Dunal,‡ who named the plant, so describes them; but the greater part of the cultivated specimens have conspicuously toothed leaves.

We have tried a number of interesting experiments with this species. A year ago one plant appeared in our plantation which bore profusely of unusually large and purple fruits, and which was very dwarf and stocky in habit. The plant was so attractive that we saved seeds of it. All the plants this year were entirely unlike the parent, being very tall growers and bearing an ordinary crop of medium green-husked fruits. But the most singular circumstance was the fact that while the plants were all unlike the parent, they were nevertheless very like each other! In other words, there was almost no variation in the offspring. Now, alongside these plants were sown unselected seeds, and from them we secured scarcely two plants alike. The first plant in the

* Hort. Eltham. t. II.

† Martyn's Miller's Dict. *Physalis* no. II.

‡ D. C. Prodr. xiii (i). 449.

row, for instance, was low and straggling (only 16 in. high), the branches lying almost horizontal ; the leaves were small and the branches green. The second plant in the row was erect (growing 3 ft. high), with large leaves and purple branches. The first nine plants represented nine very different types, the differences being, in some cases, even greater than those which ordinarily distinguish well marked varieties of cultivated plants. Numerous attempts have been made to cross-pollinate this species, but without success.

In conclusion, we may say that three species of *Physalis* or husk tomato are cultivated for fruit. One of these, variously known as the Strawberry Tomato, Golden Husk Tomato, Dwarf Cape Gooseberry and Improved Ground Cherry, is well worth growing in the home garden. The true Cape Gooseberry is too late for this latitude. The pepper-leaved *Physalis*, erroneously known as *Physalis edulis*, is unfit for general cultivation for fruit, although it is an interesting plant to the experimenter.

PEPINO.—*Solanum muricatum*.

Within the last few years a novelty has appeared in the seedsmen's catalogue under the name of Pepino, Melon Pear, Melon Shrub, and *Solanum Guatemalense*. Its botanical affinities, as well as its horticultural merits, have been a perplexity. We have now grown the plant for two seasons, in the house and out of doors, and it has proved so interesting and unique that I have prepared this account of it.

The plant is a strong growing herb or half shrub in this climate, becoming two or three feet high and as many broad. It has a clean and attractive foliage, comprised of long-lanceolate nearly smooth very dark green entire leaves. It is a profuse bloomer, the bright blue flowers reminding one of potato flowers. But one fruit sets in each flower cluster, and as this grows the stem elongates until it reaches a length of from four to six inches. The fruit itself is very handsome. As it ripens it assumes a warm yellow color which is overlaid with streaks and veins of violet-purple. These fruits are somewhat egg-shaped, conspicuously pointed, and vary from two and a half to three and a half inches in length. The illustration, Fig. 7, shows the natural size of an average specimen. If the fruits are still green upon the approach

of frost, they may be placed in a cool dry room where, in the course of two or three weeks, they will take on their handsome color. If carefully handled or wrapped in paper, the fruits will keep until mid-winter or later. The fruit is pleasantly scented, and the flavor of it may be compared to that of a juicy, tender and somewhat acid egg-plant. It is eaten either raw or cooked.

Upon the approach of winter we dig up some of the plants and remove them to the conservatory or forcing-house. It is in the capacity of ornamental plants that they will probably find their greatest usefulness in this latitude. The habit is attractive, the flowers bright and pleasant, and the fruit—if it is obtained—is highly ornamental and curious. The plant will stand a little frost.

The plant has not fruited freely with us, however, although it blooms profusely. We have endeavored to insure fruiting by hand pollination, but without success. The anthers give very little pollen. Perhaps half the plants succeed in setting two or three fruits apiece. All the fruits which we have raised have been entirely seedless, and this appears to be the common experience. The seed-cavities remain, however, as shown in the cross-section in Fig. 7. The plant must be propagated by cuttings or layers, therefore. We obtained our stock from a botanical specimen which I obtained from Florida, and which was not thoroughly dried.

This plant was introduced into the United States from Guatemala in 1882 by Gustav Eisen, of California.* There has been much speculation as to its nativity and its true botanical position. At first it was thought by some to be a variety of the egg-plant,† but it is very distinct from that species. But the plant is by no means a novelty to science nor even to cultivation, for it was accurately described and figured so early as 1714 by Feuillée in his account of travels in Peru‡. He called it *Melongena laurifolia*. At that time the plant bore "several little lenticular seeds, one line broad." It was carefully cultivated in gardens, and the Indians ate it with delight. The taste is described as somewhat like a melon. Eating too heartily of it was supposed to bring on

* Orch. and Gard. x. 61 (1888).

† Gard. Monthly, xxix. 24, 48, 84, 120, 355 (1887).

‡ Journ. Obs. Phys. Math. et Bot. 735, t. 26.



FIG. 7.—*Pepino* (*Solanum muricatum*, Aiton).

fevers. In Lima it is called Pepo. In 1799 it was again described and figured by botanists visiting Peru, Ruiz and Pavon.* They described the fruit as "ovate, pointed, smooth and shining, white variegated with purple, hanging, of the shape of a lemon." They say that it was much cultivated in Peru, and added that it was propagated by means of cuttings. It was called "Pepino de la tierra." In 1785, Thouin, a noted French gardener, introduced it into Europe, and four years later Aiton, of the Royal Garden at Kew, England, named it *Solanum muricatum*.† The specific name, *muricate* or *prickly*, was given in reference to the rough or warty character of the sprouts which spring from the root and which are often used for propagation. And now, over a hundred years later, it has found its way to us.

Mr. Eisen's account of the pepino will be interesting in this connection. "The Central American name of this plant," he writes "is pepino. Under this name it is known everywhere in the Central American highlands, and under this name only. But as pepino in Spanish also means cucumber, it was thought best to give the plant an English name. I suggested the name melon shrub, but through the error or the wisdom of a printer the name was changed to melon pear, which I confess is not very appropriate, but still no less so than pear guava, alligator pear, rose apple, strawberry guava, mango apple, custard apple, etc. * * *

As to the value of the fruit and the success of it in the States, only time will tell. The fact that I found the plant growing only on the high land where the temperature in the shade seldom reaches 75° Fahr., suggested to me the probability that it would fruit in a more northern latitude. In California it has proved a success in the cooler parts, such as in Los Angeles city, and in several places in the coast range, and will undoubtedly fruit in many other localities, where it is not too hot. * * *

My friend, the late Mr. J. Grelck, of Los Angeles, had a plantation of 10,000 pepinos, which grew and bore well and he sold considerable fruit. * * * In pulp and skin the pepino resembles somewhat the Bartlett pear, but in taste more a musk melon; but it has besides a most delicious acid, entirely wanting in melons and quite peculiarly its own. In warm localities this acid does

* Flora Peruviana, ii. 32, t. 162 a.

† Hort. Kew. i. 250.

not develop, and this fact is the greatest drawback to the success of the fruit. The fruit has no seed, as a rule. And in all, I have found only a dozen seeds, and those in fruit which came from Salama in Guatemala, a place rather too warm to produce the finest quality of fruit. The botanical name of the pepino is not known to me with certainty. The same was described by the Franco-Guatemalan botanist, Mr. Rousignon, as *Solanum Melongena Guatemalense*, but it is to me quite evident that this solanum is not, nor is it closely related to the *S. Melongena* or egg-plant, which latter is a native of Central Asia. The pepino is probably a native of the Central American highlands, and appears to have been cultivated by the Indians before the conquest by the Spaniards."* Last year Mr. Eisen writes that "it has only succeeded in Florida, but has there proved of considerable value."†

The greatest fault of the pepino appears to be its failure to set fruit. Mr. Eisen states that in Guatemala it "yields abundantly, in fact enormously, 100 to 150 fruits to a vine four feet in diameter being nothing uncommon. I have seen it yield similarly in California, but whenever exposed to too much heat and dryness, it is very slow to set fruit."‡ He recommends that it be shaded if it refuses to set fruit. Martin Benson, Dade Co., Florida, writing to the *American Garden*,|| says that he has had great success with it. "I counted the fruit on a medium sized plant and found it bore sixty, of all sizes, from those just set to some nearly matured and weighing upwards of a pound. The fruit varies considerably, but averages about the size of a goose egg. The fruit is the most perfectly seedless of any I have ever seen, without a trace of a seed. It requires cool weather in order to set fruit, and never does so excepting during a norther or other cool spell, when the fruit sets in great quantities." Mr. Benson's letter is accompanied by an admirable illustration of the fruit. In the northern states it has always proved a shy bearer, if I may judge from such records as exist. "D," writing to the *Gardener's Monthly*, says that he had "only about two pears to each plant,

*Gard. Monthly, xxix. 84 (1887)

†Gard. and Forest, iii. 71 (1890).

‡Orch. and Gard. x. 61 (1888).

|| ix. 265 (1888).

among literally hundreds of blossoms."* *Orchard and Garden*† comments upon this feature as follows: "The general experience with it here [New Jersey], thus far, seems to justify us in calling it exceedingly shy in setting fruit, and if this tendency to abortive blooming cannot be overcome, the melon pear must be considered without practical value." These remarks are certainly counter to the statements and pictures made by some seedsmen in regard to its productiveness.

The pepino is an unusually interesting plant, and if it could be made to set fruit more freely in the north, it would be an acquisition for the kitchen garden and for market. It is a good ornamental plant. Altogether, it is deserving of a wider reputation.

CHOROGI.†—*Stachys Sieboldi*.

Stachys Sieboldi, Miquel, Ann. Mus. Bot. Lugd.-Bat. ii. 112 (1865-6).

Stachys affinis, Bunge, Mem. Savans. St. Petersb. ii. 51 (1834), not Presenius.

Stachys tuberifera, Naudin, Bull. Soc. d'Acclim. France, 1887, 394.

In 1882 Dr. Bretschneider, physician to the Russian legation at Peking, sent to the Society of Acclimatization of France tubers of a mint-like plant which is cultivated in China. The Society transferred the tubers to Mr. Paillieux, at Crosnes, near Paris, who grew them that season, and who has since been largely instrumental in introducing the plant to the horticultural world. Three or four years after its introduction the plant began to attract attention in France and England, and in 1887 Naudin named it *Stachys tuberifera*, upon the supposition that it is really not the true *Stachys affinis*, under which name it had passed. It appears to have been grown in England about as early as in France, probably from some of the stock which Paillieux had received or which he grew the first year.|| It was first exhibited in England Dec. 13, 1887, before the Royal Horticultural Society by Mr.

* Gard. Monthly, xxix. 355 (1887).

† x. 12 (1888). This article is accompanied by an illustration of the fruit, the first to appear, apparently, in this country.

‡ Pronounced Chor'ogi: ch soft, as in *chore*; both o's long; g hard; i short, as in *it*.

|| Gard. Chron. 3 ser. iv. 608; iii. 211. Garden, xxxiv. 464.

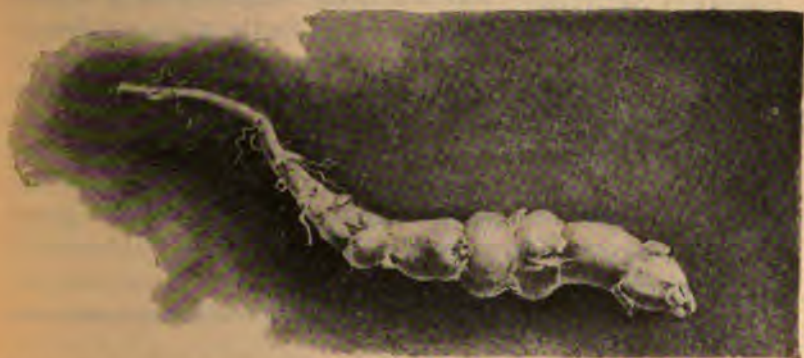


FIG. 18.—*Chorogi* (*Stachys Sieboldi*, Miquel). Detached tuber natural size.

Haskings, gardener to Sir Henry Thompson of West Mousley. It was certificated by the Society Nov. 14, 1888. It had now been introduced to the horticultural trade, chiefly by Vilmorin, of Paris, under the name of *Crosnes du Japon*, in allusion to the home of Mr. Paillieux where it had been most extensively grown, and in reference to the country whence it was supposed to have come originally. In the spring of 1888 it was introduced into this country under two names, *Stachys affinis* and *S. tuberifera*. In 1890, Hemsley, writing of the botany of China,* determined that the proper name of the plant is *Stachys Sieboldi* of Miquel.

It still remains to determine upon a good English name for the plant. Many names have been proposed, as Chinese artichoke, Japanese artichoke, knotroot, curlroot, and spirals, all of which are more or less objectionable if the plant is ever to assume any importance in trade. Some contend that the French *Crosnes du Japon* should be used, but this name does not suit an English vernacular. It is also proposed to call it by the scientific name, but a Latin name would hinder the popularizing of the plant. Again, the simple generic name *stachys* has been proposed, but as other species of *stachys* may come into cultivation in the kitchen garden, the name might lead to confusion.† It has seemed to me better to adopt some aboriginal name of the plant if a simple one can be found, and I have therefore ventured to use the Japanese name *chorogi*. This name has been suggested in English journals, but does not appear to have been adopted by any writer. Professor Georgeson, who is well known as a student of Japanese plants, and Mr. Takahashi, a Japanese student in the Cornell College of Agriculture, both inform me that this name is the one in use in Japan. The Chinese names for the plant are *kan-lu* and *tsan-yungtzu*.

Chorogi is a small perennial plant, with the aspect of peppermint or spearmint. It belongs to the mint family, and to a genus (*Stachys*) which is well represented in this country. In fact, there is some doubt among botanists as to whether it is really distinct from a common wild *stachys* (*S. palustris*) which grows in wet places over a large part of North America. Its value to

* Journ. Linn. Soc. xxvi. 301.

† We are now experimenting with an interesting tuberiferous species from Florida.

the gardener lies in the great number of crisp white tubers which it produces just under the ground. These tubers are thickened underground stems, like the potato tuber. Fig. 8 is an illustration of a plant as it appears in November, after being dug and having the earth washed from the roots. The detached tuber is natural size, and represents an average specimen as grown upon naturally poor but well enriched sandy soil. Although the tubers are small, they are so abundantly produced as to make the plant a heavy yielder. We imported tubers in the winter of 1889-90. They were in poor condition when planted, and the growth during 1890 was small. The plants were allowed to remain without protection during the winter, and this year they have spread so as to fill a row a foot and a half wide and have produced great numbers of tubers. We have eaten the tubers in several ways and I do not hesitate to pronounce the plant the most important acquisition to our list of secondary vegetables which has been made in several years. The tubers can be cooked in a great variety of ways, or they may be eaten raw. They are fried, roasted, baked, pickled, preserved, stewed in cream, and made into various fancy dishes. The tubers may be dug as wanted during the winter, and ordinarily enough of the plant will be left in the ground to propagate it the following year. The greatest fault with the vegetable is the fact that the tubers shrivel and spoil if exposed to the air for a few hours. This will interfere with their market qualities. They can be kept in earth, however, and the French market them in moist shavings, or in sawdust. Much of their value depends upon their crispness.

This plant has been much advertized, and as it bids fair to become a vegetable of some importance, I have collected here the experiences of various growers with it.

"The *Stachys tuberifera*, a so-called new vegetable from northern Africa [China], was tested, but cannot be pronounced a very great acquisition. It belongs to the mint family, and produces small fleshy tubers, which in our trial only attained the size of acorns. Its table qualities were not tested."—*Professor Goff, before Western N. Y. Hort. Soc. 1889, 28.* Our opinion was much the same as Professor Goff's at the close of our first season of test, but during the second year, the plants not having been dis-

turbed, the yield was wonderfully increased, and one plant yields a mess sufficient for a family of four.

"The tubers, which are the edible part, are produced in such an abundance as to be truly wonderful, as many as 300 having been grown from a single tuber in one season. * * * Their uses and best modes of preparation for the table are not yet known. We find by mashing them and preparing as we do egg-plant, that they closely resemble the latter, having that pleasant, spicy characteristic flavor; and as they are as easily kept as potatoes, it is a real treat to have this very good substitute in the winter. They are also good when fried or roasted."—*John F. Rupp, Pennsylvania, in Pop. Gard. iv. 122 (1889).*

"*Stachys tuberifera* is perfectly hardy in the north of France, and accommodates itself to various soils and conditions. The tubers are small, but each plant bears a great number of them, and it is very easy to harvest them. It is essentially a winter vegetable, the tubers forming late in summer and being dug in November. It is preserved anywhere under the soil, and is not injured by the frost of winter."—*Chas. Naudin, in Manuel de l'Acclimateur, 507 (1887).*

"A year ago the Dutch horticultural journal *Sempervirens* asked for reports upon *Stachys tuberifera* for European cultivation as an article of food. Twenty-one reports were submitted, among which seventeen were favorable, recommending the plant as a valuable addition to the list of table vegetables. Good sandy soil, not too dry, is said to be the best for it, as the tubers then become beautifully white, while in heavier soil they assume a brownish color."—*Gard. and Forest, ii. 144 (1889).*

"The new vegetable * * * seems to be winning its way in Germany. It was put to proof in the proverbial way at a recent meeting of the Society for the Promotion of Horticulture in Berlin, being eaten both boiled and roasted. Some who tested it pronounced roast potatoes much better, but the majority, says a German journal, declared that the stachys tubers have a 'fine, peculiar taste, and should be highly recommended to the epicure'."—*Gard. and Forest, ii. 600.*

"The new vegetable, *Stachys affinis*, has become quite popular in France, and is found now in all the principal fruit shops in Paris, the price varying from twelve to twenty-five cents a pound.

At Amiens, one of the principal centres of production, it has been sold for fifteen francs [about \$3] a hundred pounds. Some one in that city conceived the happy idea of making a preserve of the tubers. Prepared in this way they lose nothing of their quality, and the question of keeping them is settled."—*Gard. and Forest*, ii. 624.

"I have now grown this new vegetable * * * for several years, and find it well worth extensive cultivation. It is much esteemed as a second course vegetable, and it is also a useful ingredient in the salad dish, looks well, and is very palatable as a pickle, and is a fitting companion to the breakfast radishes. *

* * The yield is quite a bushel to about 16 square yards."—*P. Middleton, Gard. Chron.* 3 ser. iii. 211 (1888).

"Where stachys has once been planted, there is always a difficulty in ridding the land of them, and it is as troublesome as couch-grass."—*W. A. Cook, in Gard. Chron.* 3 ser. viii. 667.

The following account of forcing the plant is interesting : "Sets [tubers] were planted in 12-inch pots in December, the temperature maintained being 50° to 55°. I have also grown it in cold frames, with good result, having as many as 100 tubers on one plant."—*J. Claydon, in Gard. Chron.* 3 ser. iii. 469.

Several chemical analyses of this vegetable have been made, as follows :

Lhôte : *

Starch	17.80	per cent.
Albumen (including 0.69 N.)	4.31	"
Fatty matters	0.55	"
Woody matters and cellulose	1.34	"
Mineral matters (including 0.28 phosphoric acid	1.81	"
Water	74.19	"

100.00

Paillex and Bois :

"The analysis given shows 78 per cent. of water, 1.50 of nitrogenous matters, 1.67 of amides, and 16.5 per cent. 'galactane'—a newly discovered carbohydrate—a substance allied to dextrine, and intermediate between starch and sugar. In the dry state the percentage of this substance is stated to be as high as 76.7, so that the nutritive value is high, particularly as the proteic matters are cited as 6.6 per cent."†

* Reported by Carrière, *Revue Horticole*, lvii. 237 (1885); also in *Gard. Chron.* 3 ser. iii. 16 (1888).

† *Gard. Chron.* 3 ser. vi. 164 (1889), abstr. from *Revue des Sci. Nat. Appl.*

Church :

"It appears that they contain 78 per cent. of water, 1.5 per cent. of albuminoids, 1.7 per cent. of non-albuminoids or amides, 16.6 per cent. of sugars, .7 per cent. of fibre, .1 per cent. of ash, .2 per cent. of fat, and a trace only of starch."*

Planta:†

	Fresh.		Dry.
Water.....	78.33 per cent.		
Protein.....	1.50 "		6.68 per cent.
Amides	1.67 "		7.71 "
Fat (ether extract).....	0.18 "		0.82 "
Nitrogen-free extract.....	16.57 "		76.71 "
Crude fiber.	0.73 "		3.38 "
Ash	1.02 "		4.70 "
Dry substance	21.67 "		100.00

At Cornell :

Water, 78.9 per cent.

Protein, 12.04 per cent.

Ash, 1.09 per cent.

The phosphoric acid, potash and lime are present in the ash as follows :

P₂ O₅ .19 per cent.

K₂ O .64 "

Ca O .03 "

All these analyses show that chorogi rates fully as high as potatoes in food and fertilizer value.

From the foregoing experiences, it appears to be safe to recommend the chorogi for trial in every home garden.

* Before Royal Hort. Soc. Reported in Gard. Chron. 3 ser. iv. 708 (1888).

† Landwirtsch. Versuch-Stat. xxxv. 478 (1888).

NOTE.—Aside from the references given in this article, the student may find the following discussions of the species: Franchet and Savatier, Enum. Pl. Jap. i. 379. Maximowicz, Bull. Soc. Imper. Nat. Moscow, liv. 46 (1879). Pailleux and Bois, Bull. Soc. Nat. d'Acclimation de France, 1884, 44 and 280; 1885, 196; 1889, 580 and 634 (illustr.). Revue Hort. 1885, 236; 1887, 266 (illustr.). Bull. Soc. Tosc. Ort. 1886, 68 (illustr.) Le Jardin, 1887, 8 (illustr.). Franchet, in Mem. Soc. Sci. Nat. Cherbourg, xxiv. 243. Dammer, in Humboldt, May, 1888. Dufour, in Chronique Agric. et Viticole du Canton de Vaud, Apr. 1888. Vöchting, in Botanische Zeitung, xlvii. 502, 1889 (illustr.). Gard. Mag. 1888, 779. Sahut, in Ann. Soc. Hort. et Nat. Hist. Hérault, xxii. 46 (1890).

SPANISH SALSIFY.—*Scolymus Hispanicus*, Linn.

A vegetable which promises to be of considerable value in this country, if once generally introduced, is the so-called Spanish salsify, a native of southern Europe. I have grown this for two years. It makes a root much like salsify, except that it is much lighter colored and considerably longer. Its flavor is less pronounced than that of the salsify, but when carefully cooked it possesses a very agreeable quality which is somewhat intermediate between that of the salsify and parsnip. It is adapted to all the methods of cooking employed for those vegetables. The particular value of the vegetable, aside from affording a variety in the kitchen garden, is its large size and productiveness as compared with the salsify. We raise almost twice the crop upon a given area than we can secure from salsify, and no doubt it could be sold for that vegetable in the

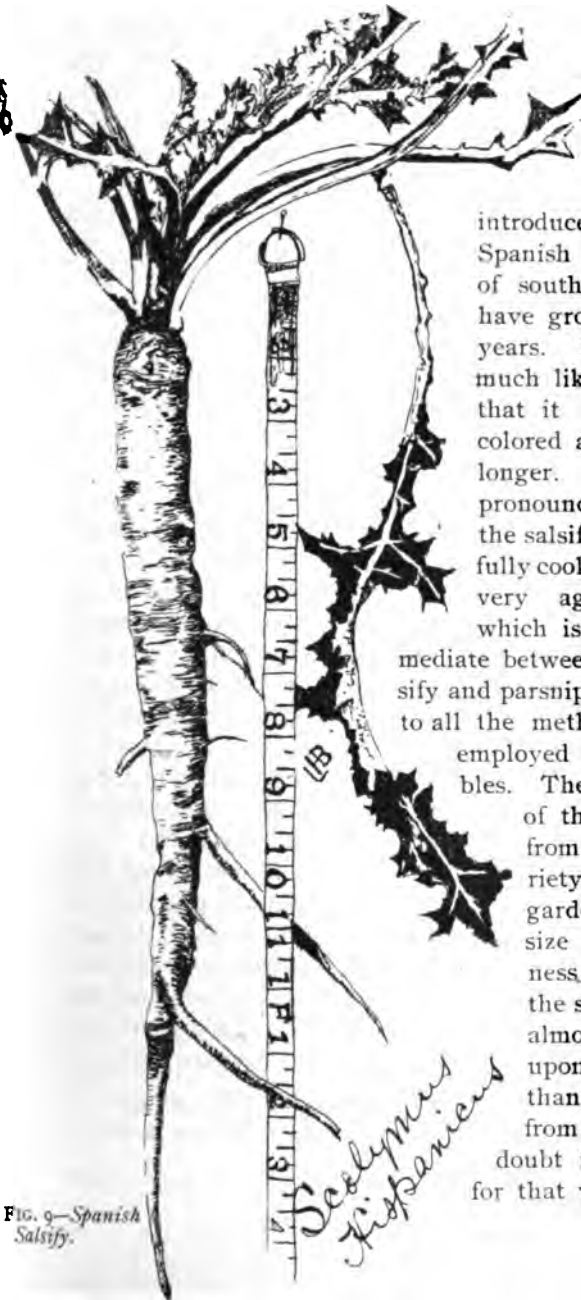


FIG. 9—Spanish Salsify.

general market. The seeds are much easier to handle and sow than those of the salsify. It is sown and cultivated in exactly the same manner as that vegetable, and can be dug either in the fall or spring. Fig. 9 shows a good root. Perhaps the greatest disadvantage of the plant is the very prickly leaves, which may make it unpleasant to handle. But on the whole, it is worth introduction into American gardens. Seeds are offered by some American seedsmen.

Spanish salsify is closely allied to the cardoon and artichoke, and its young leaves are sometimes bleached and eaten like cardoons. Nicholson, in Dictionary of Gardening,* writes that "the roots of *Scolymus Hispanicus* are equally as good as scorzonera [the black salsify]; the leaves and stalks are eaten as cardoons by the people of Salamanca; the flowers are employed for the adulteration of saffron." Naudin, who is one of the highest authorities upon cultivated plants, makes these remarks about the species: † "It is a compositous biennial of the Mediterranean region, common in the middle of France and Spain, utilized as a vegetable, but cultivated only in Spain, especially about Madrid. The plant is spiny and has the appearance of a yellow-flowered thistle. In France only the root is eaten, and this resembles that of the salsify; in Spain the midribs and petioles of the leaves are eaten, and these are sold in great quantities upon the streets of cities during many months of the year. As with other plants, this is capable of amelioration by cultivation, and it is to be regretted that it is neglected in France and that people are content to gather it in the wild state. The root is a better vegetable than that of the salsify or the scorzonera." The plant was brought to the attention of American gardeners nearly thirty years ago by Burr.‡ He gave directions for its cultivation, and wrote as follows of the quality: "They have a pleasant delicate flavor and are considered to be not only healthful, but remarkably nutritious." An account of it is given in the American Horticultural Annual for 1871, and the following remarks are made: "It does not seem to be quite as hardy as the salsify, some of our plants which were left out for experiment being found partly decayed in the spring-

* Vol. iii. 394. See also Vilmorin's Veg. Garden (Eng. ed.) 249.

† Manuel de l' Acclimateur, 491 (1887).

‡ Vegetables of America, 87.

The root is considerably larger than the salsify, and less trouble to prepare, does not require so much care in cooking to prevent it from turning dark-colored, and has a milder flavor, which is by some preferred to that of the salsify. On the other hand the plant, being prickly, is somewhat unpleasant to handle, the roots being longer and more brittle are more difficult to dig, and the center is somewhat fibrous. The last named difficulty is overcome by the French by first boiling the roots, then splitting them longitudinally and removing the tough center, which readily separates from the outer portion, which is very tender." We have not found tough centers in our plants.

THE INFLUENCE OF THE DEPTH OF TRANSPLANTING UPON THE HEADING OF CABBAGES.

For three consecutive seasons we have endeavored to determine what foundation there may be for the common notion that deep-set cabbage plants give better heads and a larger proportion of heads than those set at the normal or natural depth. It is a very general practice among gardeners to set the plants to the depth of the first leaf when transplanting to the field. The results of three years' tests show that no advantage is to be gained by such practice. In 1889* the experiment was tried upon 12 varieties, about 20 plants of each being set up to the first leaf, and as many more set to the same depth at which they stood in the seed-bed. Strangely enough, one-half the varieties gave better results from shallow setting and the other half better from deep setting. There were more heavy heads from the deep setting, however: 270 cabbages gave better results from shallow planting and 295 heads better from deep planting. The total average gain in weight apparently due to deep setting was 2 oz. per head. These 12 varieties were distributed into 13 lots—that is, one variety was grown twice,—and of these, three lots were sown July 2nd. for a late crop. Two of these three late sowings gave better results from deep setting, but the third lot, which gave better results from shallow setting, gave a greater increase in weight than either of the others. Combining all the results, it was found that the gain in weight of heads from deep setting was as 13.60 is to

*Bull. xv. 209.

13.46. This is a very small gain, and when studied in connection with the many conflicting results among the different lots, leads to the conclusion that the particular method of planting probably had nothing to do with the yields, for variations equally as great, and many times much greater, come from lots treated in the same manner.

In 1890* the test was repeated, the Early Wakefield cabbage being used for the purpose. The plants were grown upon a heavy and rather poor clay loam. The numerical results were as follows :

	Total no. of plants.	No. of mature or solid heads.	Per. cent of plants pro- ducing mature hds.	Average weight per. hd.
Deep	107	82	77	1.6 lbs.
Shallow	104	89	85	1.8 lbs.

Here the shallow planting gave decidedly the better results, both in the percentage of plants producing good heads and in the average weight of heads.

In 1891 the test was again repeated, this time with Early Wakefield and Premium Drumhead. The plants were grown on a rich and well prepared loose clay loam, and all the conditions throughout the season were such as to insure a fair and uniform test. The results of this test are the following :

	Total no. plants.	No. of mature heads.	Per cent. of plants pro- ducing mature hds.	Average. weight per head.
Early Wakefield—Deep.....	71	70	98.6	4.26 lbs.
Shallow.....	61	55	90.6	4.24 "
Premium Drumhead—Deep..	30	29	96.6	5.19 "
Shallow.....	45	45	100.	5.37 "
Average—Deep			97.6	4.72
Shallow			95.3	4.80

The average result is in favor of the shallow setting so far as weight of heads is concerned, but in favor of deep setting in the percentage of plants producing good or mature heads; but the differences are slight, and are such as might be expected from two or more lots of plants treated in the same manner. The two varieties give different results, however. The Early Wakefield gives the better results from deep setting, while the Drumhead gives better results from shallow setting. In view of these con-

* Bull. xxv. 178.

flicting results, I cannot look upon the differences as due to the manner of setting.

In conclusion, we find, as a result of three years' investigation, that the depth at which strong and stocky cabbage plants are set does not influence the extent or weight of the crop.

THE VERBENA MILDEW.

The verbenas mildew (*Oidium erysiphoides*), which is often very destructive to house-grown plants, has been held in check in our houses by the use of sulphide of potassium ($\frac{1}{4}$ oz. to a gallon of water). A lot of thrifty and stocky young plants which were badly attacked was divided into two lots for treatment, the lots being placed in separate houses. The treated plants received a spray of the sulphide about twice a week, and although a little of the mildew could always be found, the plants were not injured. The check lot was ruined, and the plants died. It is probable that copper compounds, as the ammoniacal carbonate of copper, will be found still more effective, but our simple treatment was so successful that we found no occasion to try any other. This mildew appears upon the leaves and young shoots in white mold-like patches.

L. H. BAILEY.

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Cornell University Agricultural Experiment Station.

HORTICULTURAL DIVISION.

THE CULTIVATED NATIVE
Plums and Cherries.



By L. H. BAILEY.

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BULLETINS OF 1892.

38. The Cultivated Native Plums and Cherries.

THE CULTIVATED NATIVE PLUMS AND CHERRIES.

I. THE PLUMS.

§ 1. CLASSIFICATION OF THE CULTIVATED NATIVE PLUMS.

- A. The Americana Group.
- B. The Wild Goose Group.
- C. The Miner Group.
- D. The Chickasaw Group.
- E. The Marianna Group.
- F. The Beach Plum.
- G. *Prunus subcordata*.
- H. Hybrids.
- I. Unclassified Varieties.

§ 2. CULTIVATION OF THE NATIVE PLUMS.

1. Impotent Varieties. Planting.
2. Propagation.
3. Varieties.
4. Insects and Diseases.

Since the introduction of the Wild Goose plum some forty years ago, there has been a steadily growing interest in the amelioration of our native plums. The native species possess certain advantages over the common plums of the *Prunus domestica* type,* and they are so widely distributed and are naturally so variable that they have been easily brought into cultivation under a great number of forms. Over 150 varieties have been named and more or less disseminated, and the following pages record 140.

* The common plums and the prunes belong to the European species *Prunus domestica*. In the following pages these fruits are often referred to as the *domestica* plums.

There has been no attempt, so far as I know, to make a comprehensive study of these fruits, and as a consequence our knowledge of them is vague and confused. In fact, the native plums constitute probably the hardest knot in American pomology. The botanical status of the native plums is equally unsatisfactory, and the group is one of the most inextricably confused of any one of equal extent in our whole flora. There are few botanical features which are reliable in the characterization of the species, and the specimens which are preserved in the leading herbaria are few and unsatisfactory. There is probably no group of American plants in which the characters of growing trees and fresh fruits are more essential in the distinguishing of species than in these plums. Yet there are the most remarkable variations in habit of tree, seasons of blooming and ripening, size, flavor and texture of fruit, and characters of stone, even among varieties coming presumably from the same species. Fully half of the varieties now in cultivation were picked up in woods and copses and transferred to the orchard, and the variations between these varieties are fully as great as between those of known or garden origin. There is evidence that hybridity is responsible for some of the variation of cultivated forms, but whether it takes place in nature is wholly a matter of conjecture. It is an unsafe principle to invoke the aid of hybridity, upon purely speculative grounds, to explain doubtful points; and I have therefore referred doubtful forms directly to the most closely allied species or type, so far as possible, leaving speculations as to their true affinities to future students. The native plums can be commended with confidence to any one who desires to study contemporary evolution.

In the following study, which has now extended through six years, I have had the co-operation of many botanists and horticulturists. I am under especial obligations to all those whose names are mentioned in this paper, particularly to J. W. Kerr, Denton, Maryland, and T. V. Munson, Denison, Texas. Without the aid given by these last two persons the preparation of this monograph would have been impossible. Mr. Kerr probably has the largest growing collection of native plums in existence, and I have had the advantage of a personal inspection of his orchards

in the fruit season. I have had access to the herbarium collections at Harvard University, Columbia College, Department of Agriculture, and the Engelman Collection of the Missouri Botanical Gardens. Several botanists have favored me with material, especially Dr. C. E. Bessey, University of Nebraska, Dr. T. C. Porter, Easton, Penn., and H. N. Patterson, Oquawka, Illinois. And I have enjoyed the great advantage of having had the advice of Professor C. S. Sargent, who has critically examined some two or three hundred of our specimens. In the following descriptions, those varieties marked C are in cultivation at Cornell.

§ 1. *Classification of the Cultivated Native Plums.*

A. THE AMERICANA GROUP. (*Prunus Americana*, Marshall, *Arbustrum Americanum*, III, [1785]).

To this type belong the hardy, strong growing varieties which have come from the northwest, and which are characterized by a firm, meaty, usually compressed, dull-colored late fruit, with thick and usually very tough, glaucous skin, and large more or less flattened stone which is often nearly or quite free, and by large obovate, thick, veiny, jagged, dull leaves. *Prunus Americana* is generally distributed throughout the Northern States from Western New England to Kansas and Nebraska, and to the mountains of Montana and Colorado, in the middle longitudes reaching as far north as Manitoba and as far south as Texas and even northern Mexico. Notwithstanding its wide range, most of its cultivated varieties have come from its northwestern limits, as northern Illinois, Wisconsin, Minnesota, Iowa and Kansas. This fact is indication that the western plum may be a distinct species from the eastern and southwestern types, and I should not be surprised if we ultimately find this to be true. I have looked in vain, however, for characters with which to separate them. Professor Sargent is of the opinion that the *Prunus nigra* of Aiton should be revived to designate those forms which are characterized by very flat and smooth stones, very broad leaves, glandular leaf-stalks and calyx lobes, and large flowers. To this species he would refer the Weaver, the stones of which, as shown in Fig.

1, are very large, flat and smooth. After the most careful study, however, I am unable to find any constancy in these characters, especially in cultivated varieties. Even in wild specimens, the flat stone of *P. nigra* is often associated with the glandless leaf-stalks of *P. Americana*, and *vice versa*; and there appears to be equal inconstancy in the characters of calyx lobes and sizes of flowers. In fact, the same cultivated variety, when grown in different places, has been referred to both species. I am obliged, therefore, for the purposes of this paper, to unite *Prunus nigra* with *P. Americana*. This I regret the more because it is undoubtedly true that there are two well marked wild varieties—possibly species—passing as *P. Americana*, and growing together in the East. One is a twiggy, virgate grower, with large and mostly earlier flowers; the other is a stout and stiff grower with small flowers. So far as I have been able to determine, the fruits and stones of these two forms, save possibly in time of ripening, are not characteristically distinct. These forms are certainly common in central New York and in Michigan, where I have often observed them. Dudley records them in Cayuga Flora.* Some of these differences are detailed in the following letter from Professor Charles A. Davis, of Alma, Michigan, accompanying specimens of the trees mentioned. The specimens were referred to Professor Sargent, who places the first or large-flowered form with *P. nigra* and the small-flowered form with *P. Americana*. "The large-flowered form is the more common and blooms about a week or even ten days before the other, and usually before the leaves begin to appear. The small-flowered form I have never found until this spring, when I came upon a clump of it in full bloom, and at once became interested in it because of its decided differences from the other and common form. The trees were larger, more spreading, and with a much rougher bark than the large-flowered form; and a number of the trees bore flowers with a decidedly yellowish tint, which was very noticeable from a short distance. The fruit was late, maturing the middle of September, and was reddish, almost purple in very

* The Cayuga Flora, Ithaca, N. Y. 1886, p. 27. See also Flora Chicago.

ripe specimens, with a whitish bloom, small and rather palatable." It is easy to place too great confidence in the seasons of blooming and ripening, for these characters are variable. This is well illustrated in the case of the Late Rollingsstone plum, which is a seedling from the Rollingsstone—itsself a wilding—but which is three weeks later in ripening than its parent.

The fruits of wild forms of *Prunus Americana* vary widely in season, size, shape, flavor, and character of stone. Trees in the same clump often vary two weeks in season of ripening of fruit, which may vary from dull deep red to yellow. It should be said, however, that there is no true clear yellow fruit in this species. The yellow of *P. Americana* is always a more or less ill-defined under color, over which are laid blotches of red. The fruits are more or less flattened, as is well shown in Fig. 1, usually oblong and truncate or somewhat flattened at the ends, and are commonly marked with a distinct suture. All the varieties have a light purple bloom.

The Texan form of *P. Americana*, known locally as the Hog plum, appears to differ somewhat from the northern forms, and it may be a distinct species. It has the glands, both of calyx and leaf-stalks, of the *P. nigra* form and the rounded stones of true *P. Americana*. The plant is not in cultivation, however, and need not be further discussed here.

Prunus Americana was founded over a century ago by Humphrey Marshall. His description, particularly of the leaves, is peculiarly characteristic of the wild plum of the north. It is as follows :

"*Prunus Americana*. Large Yellow Sweet Plum. This generally rises to the height of 12 or 15 feet, spreading into many stiff branches. The leaves are oblong, oval, acute pointed, sharply sawed on their edges and much veined. The flowers generally come out very thick round the branches, often upon thick short spurs; and are succeeded by large oval fruit with a sweet succulent pulp. We have a great variety of these, growing naturally in a good moist soil, with reddish and yellowish fruit, but differing much in size, taste and consistence."

West of the Mississippi there is a form of *Prunus Americana*

with conspicuously pubescent and often glaucous leaves and shoots. This is the variety *mollis*, a plant which is commonly supposed to be confined to Texas and its northern borders. It certainly grows as far north as Iowa. The varieties known as Wolf and Van Buren belong here.

The following cultivated varieties belong to *Prunus Americana* :

1. *American Eagle*.—Fruit and flowers unknown to me. Leaves rather large, the stalks glandular. Introduced in fall of 1889 and spring of 1890 by Osceola Nursery Co., Osceola, Missouri. C.

2. *Beaty's Choice*.—Fruit large, round-oblong, red-purple or red-blue, skin medium thick : flesh firm, of high quality : cling, the stones broad, flat and smooth, like those of Weaver ; flowers large, conspicuously stalked in large clusters, calyx lobes reflexed, glandless, smooth or nearly so on the inside. Late. Originated under cultivation in Southern Texas by Lee Beaty. T. V. Munson says that it appears to be a hybrid between *Prunus Americana* and *P. domestica*. Ripens at Denison, Texas, from the first to the middle of August.

3. *Black Hawk*.—Known to me only from a record in Bull. 4, Iowa Experiment Station, by R. P. Speer (Feb., 1889), in which "a nameless variety found in Black Hawk County, and a very large and beautiful free-stone plum, which was furnished by Mr. Slater of Story County," was tested as to culinary qualities in comparison with Miner, Weaver, Bassett, Rollingstone, Moreman, Wolf, De Soto and Maquoketa. "The decision of all who tasted the same was that the Maquoketa and Black Hawk plums were equally good and much better than any of the other kinds except the De Soto, which was marked good; but second in quality. The skins on the Maquoketa and Black Hawk plums were so thin that they disappeared almost entirely while being cooked." I do not know that the variety has been introduced. Presumably *P. Americana*.

4. *Brainerd*, in cultivation in Minnesota (O. M. Lord), probably belongs to this species.

5. *Cheney*.—Fruit large to very large, round-oblong, scarcely flattened, dull purplish red, skin thick : flesh firm and sweet, good to very good : cling, the stone very flat and smooth with rather rounded ends ; flowers not large, the calyx lobes glandular, smooth inside ; leaves medium, long-pointed, leaf-stalks glandular. Early for the group, ripening even in Minnesota by the middle of

August. One of the best varieties. Found in Morman Ravine, a few miles below La Crosse, Wisconsin, and introduced by E. Markley, La Crosse. C.

6. *Chippeway*.—Fruit small to medium, oblong, deep red, the skin medium thick: flesh firm and sweet: stone free, small, strongly convex on the sides and pointed, roughish; leaves medium, rather strongly pubescent beneath, leaf-stalks glandular. Has gained no prominence so far as I know.

7. *Cottrell*.—Fruit large, round-oblong, red, skin thin: flesh rich and agreeable: cling; leaves large, comparatively thin and smooth, leaf-stalks glandular. Medium season. Seedling raised by R. L. Cottrell, Dover, Olmsted Co., Minn., and introduced in 1888 by O. M. Lord of Minnesota City.

8. *Deep Creek*.—Medium size, round-oblong and prominently flattened and bearing a conspicuous suture, dull purple-red, very glaucous, skin thick: flesh firm, and very sweet and good: stone free, sides convex, long-pointed, roughish; flowers rather small, short-stalked, the calyx lobes glandless and hairy inside; leaves medium, nearly smooth, stalks glandular. Medium season. A Kansas wild variety, introduced by Abner Allen. C.

9. *De Soto*.—Large to very large, round-oblong, purple-red with moderate bloom, skin thick: flesh medium firm, good: stone cling, rather large, somewhat convex, rounded at the ends, slightly roughened; leaves medium, stalks glandular. Medium to late. One of the most popular varieties. Found wild on the Mississippi at De Soto, Wisconsin. Generally introduced by Elisha Hale, Lansing, Iowa, 1863 or 1864. Figured by Professor S. B. Green in Bull. 5, Minn. Exp. Sta. See No. 3, above. C.

10. *Forest Garden*.—Large, round, orange overlaid with rose-purple, skin medium thick to thin: flesh medium firm to soft, good: stone cling, convex on the sides, rounded at the ends, slightly roughened; leaves medium, rather smooth, glands none or reduced to a single small one. Medium season, ripening in Minnesota the middle of September. A good sort for home use, but does not ship well unless picked before ripe. Tree grows forked and is apt to split. Said not to succeed well east of Illinois. Taken from the woods at Cedar Rapids, Iowa, by Thomas Hare, and introduced by H. C. Raymond, of the Forest Garden nurseries, Council Bluffs, about 1862. Figured in Bull. 5, Minn. Exp. Sta., by Prof. S. B. Green.

11. *Gaylord*.—Fruit large, round-oblong and slightly flattened, deeply mottled red over a ground of orange, skin rather thick: flesh pulpy and sweet: stone moderate cling, broad and rather flat,

pointed, sharp-edged on the back, somewhat roughened; leaves rather broad, somewhat pubescent below, glandular. Medium season. Introduced recently by Edson Gaylord, Nora Springs, Iowa.

12. *Harrison's Peach*.—Medium size, round-oblong, dull red, skin thick: stone free; leaves medium, rather thick and pubescent, the glands large. Medium season. Not widely disseminated apparently. Minnesota, a wild variety. C.

13. *Hawkeye*.—Large to very large, round-oblong, purple-red, skin thick: flesh firm and good: stone cling; leaves medium firm, very smooth for the species, stalks glandular. Medium season. Originated in Iowa under cultivation. Introduced by H. A. Terry, Crescent City, Iowa, 1878. Specimens from the Michigan Agricultural College evidently belong to *Prunus angustifolia*, the Chickasaw type. C.

14. *Ida*.—I know this only from a description submitted by D. B. Wier, the originator: "Medium size, round, yellow nearly covered with dull red: flesh firm, salmon-color, very sweet: free-stone; leaves very downy and leathery; tree thorny, exceedingly sprawling. The fruit is acid when cooked, but dries sweet." Said by Mr. Wier to be pure *P. Americana*. Illinois.

15. *Illinois Ironclad*.—Fruit very large, oblong, dark red, thick skin: flesh firm: cling; leaves medium, pubescent, glands small or absent. Medium season. Said to be one of the best native plums. Wild variety from Illinois, introduced in 1890 by Stark Bros., Louisiana, Mo. C.

16. *Iona*.—Known to me only from description of the originator, D. B. Wier: "Fruit large, oblong, dull yellow with red cheek, skin medium thick: flesh firm, yellow and sweet: stone free, long and much flattened, with a sharp border on the back; leaves very large; tree strong and upright, the growth smooth. Medium season." Said by Mr. Wier to be pure *P. Americana*, the seed coming from a wild bush in southwestern Wisconsin.

17. *Itaska*.—Fruit medium, oblong, dull purple-red, skin thick: flesh firm, of fair quality: cling; flowers small and sessile, pinkish, the calyx lobes somewhat glandular, and smooth within; leaves thick and broad, stalks either glandular or glandless; tree a very short, stocky and thick grower, the short joints giving the pinkish bloom a strikingly massed effect. Medium season. One of the most distinct in habit. Minnesota. Introduced by P. M. Gideon, Excelsior, Minn., and by W. F. Heikes.

18. *Kickapoo*.—Medium, round-oblong, blotched red, thick skin: flesh firm: stone cling, convex on the sides, long, roughish;

flowers small and sessile or nearly so, calyx lobes minutely glandular and smooth or nearly so within; leaves rather small, narrow, long-pointed, very sharply toothed, pubescent below, glandless or occasionally a leaf with small glands; tree a straggling grower, very prolific. Medium season. Appears to be much attacked by shot-hole fungus.

19. *Kopp*, introduced by O. M. Lord, Minnesota, is probably *P. Americana*.

20. *Late Rollingstone*.—Very like Rollingstone (No. 35) of which it is a seedling, but three weeks later, pulp not so firm, and skin thicker. O. M. Lord, Minnesota.

21. *Le Duc*.—Medium, round and flattened, orange spotted with red, skin thin: flesh pulpy and sweet: a moderate cling, the stone rather broad with convex sides, rounded at the ends, slightly roughened. Medium season. A wild variety from Hastings, Minn., introduced by W. G. Le Duc. C.

22. *Little Seedling*.—A small red plum with small convex roughish cherry-like stones, and narrow, rather finely serrate leaves, and glands very small or none. Charles Luedloff, Carver, Minn.

23. *Louisa*.—Large to very large, round, deep red, skin thick: flesh firm and good: semi-cling, the stone broad and convex and smoother than is usual for this shape; leaves medium, long-pointed, pubescent below, glands small or none. Medium season. A wild plum found in Missouri and introduced by Samuel Miller, Bluffton, Mo. "Very similar to Weaver."—*T. V. Munson*. Flowers upon Maryland specimens are small and nearly sessile, with glandless calyx; from Texas they are large and stalked, with calyx lobes reflexed and glandular, and hairy within.

24. *Luedloff's Green*.—Medium to small, oblong and flattened, deep mottled red, skin thick: flesh firm, sweet and good: nearly free, the stone small, convex, pointed, rough; leaves rather small and smooth, glands very small or none. Charles Luedloff, Minn.

25. *Luedloff's Red*.—Much like the last, but lighter red, skin thicker, pit freer, stone rather broader and leaves pubescent beneath.

26. *Maquoketa* (Fig. 11).—Medium to nearly large, round-oblong, red, skin thick: cling, the stone very convex, short-pointed, rough; leaves medium, rather smooth, glands none or small. Medium to late. Originated in Iowa under cultivation. See No. 3.

27. *Minnetonka*.—Medium in size, round-oblong, dull red, skin thick: cling; flowers medium, calyx lobes glandless, hairy inside; leaves medium, pubescent, glandless or nearly so. Medium season. Introduced by P. M. Gideon, Minn.

28. *Mussey*.—Very large, round-oblong, yellow mottled with red, skin medium thick: flesh firm and excellent: semi-cling; leaves medium to large, pubescent, glands small or none. Very late. Wild, from Kansas. Introduced by Abner Allen.

29. *Newtown Egg*.—Medium to rather large, oblong, red, skin thick: flesh firm: free, the stone long and rather flat, scarcely pointed, nearly or quite smooth; leaves medium, nearly smooth, glands none or small. Medium season. Charles Luedloff, Minn.

30. *New Ulm*.—"Very large, round-oblong, dark red, skin medium: flesh firm and of best quality: cling. Medium to early. A Minnesota seedling introduced by C. W. Heideman, New Ulm, Minn."—*Professor S. B. Green, Minn. Exp. Sta.* Presumably *P. Americana*.

31. *Ocheeda*.—"Large, round, yellow and red, skin thin: flesh firm and of best quality: semi-cling. Medium season. Wild variety from Minnesota. Introduced by H. J. Ludlow, Worthington, Minn."—*Professor S. B. Green, Minn. Exp. Sta.* Presumably *P. Americana*.

32. *Peffer's Premium*.—Medium to nearly large, round, red, skin thick: flesh firm and good: cling, the stone nearly circular and flat, rather smooth; leaves medium with rather obtuse serratures, nearly smooth, stalks glandular. Medium season. Wisconsin seedling. Introduced by George P. Peffer, Pewaukee, Wis.

33. *Purple Yosemite*.—Very large, round, red-purple, skin thick: flesh firm: cling, stone large and flat, blunt at the ends and on the margins, nearly or quite smooth; flowers medium, short-stalked, the calyx lobes glandless and hairy within; leaves medium, comparatively smooth, stalks glandless or glands small. Medium season. An excellent plum in many places. C. M. Stark writes me that it has no value in Missouri. C.

34. *Quaker*.—Very large (1½ in. long), round-oblong and somewhat flattened, purple-red inclining to orange-red on side opposite the sun, very glaucous-blue, skin very thick and acerb: flesh very firm, sweet and juicy: moderate cling, the stone large and flat, prominently ridged and winged on the back, ends rather blunt, slightly pitted; flowers rather large, stalked, the calyx

lobes large and becoming reflexed, hairy inside but scarcely if at all glandular; leaves rather large and firm, pubescent, the glands small or sometimes wanting. Medium season. One of the best varieties. Must have the best cultivation and not be allowed to overbear. Discovered wild by Joseph Bundy, of Springville, Linn Co., Iowa. Disseminated about 1862 by H. C. Raymond, Council Bluffs, and by him named Quaker in compliment to Mr. Bundy, who is a quaker. C.

35. *Rollingstone*.—Very large (often $1\frac{1}{2}$ in. each diameter), round, flattened and truncate at the ends, mottled and spotted pink-purple, skin very thick: flesh firm, sweet and excellent: semi-cling, stone nearly circular, rather flat, sharp on the back edge, nearly smooth; flowers large, long-stalked, the calyx lobes large and rarely somewhat glandular, hairy on the inside; leaves large and firm, comparatively smooth, stalks either glandular or glandless. Medium season, coming in just before De Soto. One of the leading varieties. Found over 30 years ago on the bank of the Rollingstone Creek, Winona Co., Minn., by O. M. Lord, and by him introduced some ten years ago. Professor L. H. Pammel, of the Iowa Agricultural College, writes me that this variety is reported as the common plum along creeks at Dysart, Iowa. C.

Mr. Lord has raised many pure seedlings of the Rollingstone, of which the Late Rollingstone (see No. 20) is one. "Several years ago," he writes, "I cut out of my grounds all varieties of native plums except the Rollingstone. The object was to perpetuate the tree by seeds true to name by preventing all crossing. Some of the seedlings cannot be distinguished by their foliage or flowers, but none of them bear as good fruit as the parent. Some are later and some earlier." The variety is figured by Professor S. B. Green in Bull. 10, Minn. Exp. Sta.

36. *Speer*.—Medium, oblong, mottled orange and red, skin medium: flesh firm and sweet: semi-cling, stone broad, convex, ends blunt, slightly roughened; leaves medium, nearly smooth, stalks glandular. Iowa seedling by J. A. Speer.

37. *Van Buren* (*Prunus Americana* var. *mollis*).—Large, round-oblong, purple-red, skin thick: free; leaves medium, densely white pubescent beneath and on the stalks, as well as the young growth, stalks glandular. Medium season. The pubescence is most marked on young shoots. An Iowa wild variety, introduced by J. Thatcher.

38. *Wazata*.—Medium or even small, round, dull red, thick skin: cling; leaves medium, pubescent beneath, the glands small

or none. Medium to late. C. M. Stark writes that it has no value in Missouri. Wild Minnesota variety, introduced by Peter M. Gideon and W. F. Heikes.

39. *Weaver* (Fig. 1).—Large, round-oblong and flattened, suture prominent, orange densely overlaid with mottled red, skin thick: flesh firm, sweet and good: semi-cling, the stone large and flat, obscurely pointed, the wing or margin conspicuous, smooth; flowers large and prominently stalked, the calyx lobes usually conspicuously glandular and obscurely hairy inside; leaves large and firm, deeply toothed, slightly pubescent beneath, the glands rarely prominent and frequently entirely wanting; tree a strong free grower and prolific. Medium to late, ripening in Minnesota the last of September. A well marked variety, and one of the best. A wild variety, found near Palo, Iowa, by Mr. Weaver; introduced by Ennis & Patten in 1875. Ripens in Northern Texas from the first to middle of August. O. M. Lord writes me that "the Weaver is wild in profusion on the St. Peter or Minnesota River." Figured by Professor S. B. Green in Bull. 5, Minn. Exp. Sta. C.

40. *Wier's Large Red*.—"A round plum as large as Wild Goose and better in quality, excellent for cooking; ripening last half of September."—B. O. Curtis, Paris, Ill. Leaves medium, firm, smooth or very nearly so, the stalk glandular. D. B. Wier, Illinois.

41. *Wild Rose*.—"Large, round, yellow-blush, skin medium: flesh firm: cling. Early. A Minnesota wild variety, not propagated for sale, but deserving to be."—Sias. Introduced in 1880 by A. W. Sias. Presumably *P. Americana*.

42. *Wolf* (*Prunus Americana* var. *molis*). Fig. 2.—Large, round, yellow blotched with red, skin thick: flesh firm, meaty and good: perfectly free, the stone circular in outline with a tendency to taper towards the apex, rather flat, the wing or border pronounced, smooth; flowers medium, short-stalked, the calyx lobes glandular and hairy inside; leaves broad and thick, the blades and stalks, as well as the young shoots, prominently pubescent and often glaucous, especially on the young growth, the leaf stalks bearing no glands, or only small ones; tree a stout,



FIG. 2.—Wolf.



FIG. 1.—*Weaver*. Foliage and flowers one-half natural size. Fruits and stones full size.

good grower, prolific. Medium season. One of the best, both for home use and market. The illustration shows a medium sized specimen. Often known as Wolf Free. Originated on the farm of D. B. Wolf, Wapello County, Iowa, nearly 40 years ago, from pits said to have been taken from wild trees in the woods. C.

43. *Wyant*.—Large, round-oblong, purple-red, skin thick : flesh firm : free ; leaves medium, slightly pubescent, the glands small. Found wild in Northern Iowa by Mr. Wyant ; introduced by Professor J. L. Budd. C.

44. *Yellow Sweet*.—Medium, round-oblong and flattened, ground color orange mottled and splashed with pink-purple : skin thin : free, the stone nearly circular, rather flat and somewhat sharp on the back, rough. Minnesota? C.

45. *Yellow Yosemite*.—I am not acquainted with the fruit of this variety, but I am told by reliable growers that it is identical with Purple Yosemite.

The Americana group succeeds best, on the whole, in the northern states of the Mississippi valley, and it is the only one which is able to withstand the climates of the northernmost limits of the native plum belt, as Wisconsin, Minnesota and Iowa. There are some varieties, however, which succeed so far south as Texas. In the Atlantic States the varieties are not grown far south. At Mr. Kerr's place, on the Chesapeake peninsula, the varieties are likely to be unproductive, or short lived, and are much injured by a mysterious blight ; yet there are some kinds which grow well with him, among which I recall Wolf, Purple Yosemite and Kickapoo. The greatest profitable range of the group, however, is confined somewhat closely to the two or three northernmost tiers of States. The varieties which are most highly prized are Cheney, Deep Creek, De Soto, Forest Garden, Itaska, Louisa, Purple Yosemite, Quaker, Rollingstone, Weaver and Wolf.

B. THE WILD GOOSE GROUP.—(*Prunus hortulana*, L. H. Bailey, Garden and Forest, v. 90, [1892]). This, perhaps the most important group of native plums, includes varieties characterized by strong wide-spreading growth and mostly smooth twigs, a firm, juicy, bright-colored, thin-skinned fruit which is never

flattened, a clinging turgid comparatively small rough stone which is sometimes prolonged at the ends but is never conspicuously wing-margined, and by comparatively thin and firm shining, smooth, flat, more or less peach-like, ovate-lanceolate or ovate long-pointed leaves which are mostly closely and obtusely glandular-serrate and the stalks of which are usually glandular.

Prunus hortulana in the wild state appears to follow the Mississippi river from northern Illinois to Arkansas, in its middle region ranging so far east as eastern Kentucky and Tennessee and possibly to Maryland, and in the southwest spreading over Texas.

This species does not appear to have been recognized by writers upon the genus, although pomologists have long regarded the varieties of it as distinct from *P. Americana*. As it has come into prominent notice through the labors of horticulturists, I take pleasure in recording the fact in the name *hortulana*. The varieties are intermediate between the *Americana* and Chickasaw groups, while the Miner group, which I refer provisionally to this species, is anomalous in its characters. The fruits lack entirely the dull-colored, compressed, thick-skinned and meaty characters of the *Americanas*, and approach very closely to the Chickasaws. They are usually covered with a thin bloom and are more or less marked by small spots. They are variable in period of ripening, there being a difference of no less than two months between the seasons of some of the cultivated varieties. In color they range from the most vivid crimson to pure golden yellow. The botanical features of the species are not yet well determined, and it is not impossible that more than one species is confounded in it. Some of the gross features of the species are well illustrated in Fig. 3.

In this group B, as I have here constituted it, there are two more or less clearly marked types, but which I am not yet able to separate by positive botanical characters. One type is characterized by thin and very smooth peach-like leaves which are very finely and evenly serrate. It comprises Cumberland, Indian Chief, Roulette, and Wild Goose. The other form or type is characterized by thicker, duller and more veiny leaves which are more coarsely and more or less irregularly serrate. This includes

Golden Beauty, Kanawha, Moreman, Reed, Sucker State, World Beater and Wayland. It forms a transition to the Miner group (C).

46. *Clark*.—A variety which I know only from the growing tree. Leaves elliptic-ovate, rounded at the base and comparatively short pointed, finely serrate, the stalks 2-glandular. Recently introduced and said to have been found wild in Anne Arundel Co., Maryland. If it is really indigenous there, it greatly extends the range of the species. C.

47. *Cumberland*.—Fruit medium, oblong, yellow, skin thin: stone rather short, rounded at the base but somewhat pointed at the apex; flowers medium, short-stalked, the calyx lobes glandular; leaves ovate, rounded at the base, long-pointed, finely serrate, the stalks bearing two to several glands. Medium to late. Said to have originated in Georgia, under cultivation. Introduced by Philip Schley. C.

48. *Garfield*.—Fruit medium, round-oblong, dark red, skin thick: stone slender (twice as long as broad), prolonged at both ends; flowers medium, stalked, the calyx lobes conspicuously glandular; leaves large to very large, ovate-lanceolate, rounded at the base, rather finely serrate, the stalks usually furnished with a string of glands; tree a strong spreading grower. Late. C. M. Stark writes that it is unproductive in Missouri. Said to have been found wild in Ohio. Introduced in 1887 by the late Leo Welz, Wilmington, O. C.

49. *Golden Beauty* (Fig. 12; also illustration on title-page).—Fruit medium, round-ovate, deep clear yellow, skin medium thick: flesh very firm and of excellent quality: semi-cling, the stone small and broad (only one-fourth larger than broad), the point very short; flowers large, prominently stalked, the calyx lobes glandular; leaves narrowly ovate-lanceolate and very peach-like, rather tapering at the base, thick and dull and somewhat pubescent below, coarsely serrate, the stalk with very small glands. Late; blooms very late. One of the best. A wild south Texan variety, introduced by George Onderdonk in 1874.

Honey Drop.—See Missouri Apricot, below.

50. *Indian Chief*.—Large, round, dull red, skin medium thick: flesh firm: cling, the stone very broad and scarcely prolonged into a point, very rough; flowers medium, short-stalked, the calyx lobes glandular; leaves short, broadly elliptic-ovate, comparatively short-pointed, finely serrate, the short stalks glandular. Early. Recalls the Chickasaws. Origin uncertain: said by Munson to have originated in southern Texas, and by Onderdonk

to have come from Georgia; others say that it came from Arkansas. C.

51. *Kanawha*.—Fruit medium to large, round, red, skin medium thick: cling; leaves large and broad with long points, rather thick and dull, the edges irregular with rounded teeth and notches, with several glands on the stalks. Late. Georgia? "Similar to Wayland."—*Munson*. "Almost like Reed. Excellent for spicing. An enormous bearer."—*Berckmans*. C.

52. *Missouri Apricot (Honey Drop)*.—Medium to rather large, round, deep yellow, skin medium: semi-cling, the stone rather short and turgid, produced abruptly into short points; flowers medium, short-stalked; leaves medium in size with conspicuous points and with rather large serrations, light-colored, the whitish stalks bearing very small glands or sometimes even glandless. Late. Perhaps the best yellow plum. Quality high. Found wild in Missouri and introduced by Stark Bros. in 1886. "Every way an improvement on Golden Beauty."—*C. M. Stark*. C.

53. *Moreman*.—Medium in size, round, dark red, skin medium thick: cling, the stone small and nearly circular, the points very short; leaves medium, long-pointed, rather coarsely serrate, rather dull in texture, the stalks nearly or quite glandless. Late. A strong spreading grower, producing abundantly of handsome and high quality fruit. It suggests the Miner group and may belong to it. Originated in Kentucky. Introduced by W. F. Heikes in 1881. "Cooks well. As good as a Damson when spiced."—*Kerr*. C.

54. *Poole (Poole's Pride)*.—Large, round-oblong, red, skin medium thick: cling; leaves rather small and narrow, very finely serrate, the short stalks glandless or nearly so. Early to medium, of high quality. Succeeds Wild Goose. A wild variety from Illinois, introduced in 1888 by Stark Bros. I am not well acquainted with this variety. It looks much like a Chickasaw.

55. *Reed*.—Medium, round, dark red, skin medium: cling, the stone short and turgid, pitted, the point abrupt and short; flowers medium, short-stalked; leaves very broad (elliptic-ovate or even nearly round-ovate) and large, firm, the point abrupt and conspicuous, unevenly serrate, the stalks bearing few small glands. Late. A very strong spreading grower. Much like Moreman in fruit. Said to have been introduced by the late Mr. Reed, Hightstown, N. J. C.

56. *Roulette*.—Medium to rather large, round or round-oblong, red and coloring completely before dropping from the tree, skin thin: cling, stone (like Wild Goose) oblong-obovate and rather

slender, scarcely pointed above ; flowers medium on rather conspicuous stalks ; leaves the shape and size of peach leaves and like those of Wild Goose, the serratures small and even, the stalks glandular. Early to medium. Texan? The Mexican Roulette is evidently the same. C.

57. *Sucker State*.—Large, round, dull red, skin thick : cling ; flowers large, stalked ; leaves medium to large, long taper-pointed, irregularly and obtusely but rather finely (for the size of the leaf) toothed, stalks glandular. Medium to late. Illinois? C.

58. *Texas Bell* (or *Belle*?).—Fruit medium to large, nearly spherical, red : stone short and turgid, obtuse below and very short-pointed above ; leaves medium, elliptic-oblong and short-pointed, finely and evenly serrate, the stalks glandular. Ripens last of June in Texas. Originated by Stephen H. Turner, Texas, and introduced by J. T. Whitaker, Tyler, Texas. Perhaps a Chickasaw.

59. *Wayland*.—Fruit large, round-oblong, shining pink-red, skin medium : semi-cling, the stone rather small for the size of the fruit, turgid and slightly pitted, very short-pointed at both ends ; flowers large and long-stalked, very late ; leaves medium to large, rather thick and heavy, long-pointed, the edges irregularly serrate and notched, the stalks usually glandular. Very late. One of the best native plums, but too late for the northern states. Introduced by Downer & Bro., Fairview, Ky. First propagated in 1876. It came up in a small plum thicket in a corner of the garden of Professor H. B. Wayland, Cadiz, Ky. C.

60. *Whitaker*.—Very large, red ; leaves medium, oblong-ovate, points rather short, very finely and evenly serrate, the stalks with small glands or none. Originated under cultivation in eastern Texas by J. T. Whitaker. Seedling of Wild Goose. C.

61. *Wild Goose* (Fig. 3.).—Large, round-oblong, light red, skin thin : cling, stone long and narrow, prolonged above into a sharp point and below into a narrow base, finely pitted ; flowers medium to large, stalked ; leaves oblong-lanceolate, peach-like, not prominently pointed, the margins finely and evenly serrate, and the stalks usually bearing two to four small glands. Early. Quality poor, but on account of its productiveness, earliness, beauty, good shipping qualities, and its early introduction, it is the most popular of the native plums. The Wild Goose was first brought to notice by James Harvey of Columbia, Tenn. Some time before 1850 a man shot a wild goose near Columbia, and on the spot where the carcass was thrown this plum came up the following spring. It was introduced about 1850 by the late J. S. Downer,



FIG. 3.—*Wild Goose.* *Sprays half size. Stones full size.*

of Fairview, Ky. This is the first native plum introduced to general cultivation, although the Miner was first known and named. C.

The Wild Goose is either very variable or there are two varieties passing under that name. In the orchards of Mr. Kerr, in Maryland, and Mr. Munson, in Texas, the flowers appear before the leaves in crowded lateral clusters, but in the plantations at the Michigan Agricultural College and at Cornell, they appear with the leaves in diffuse cherry-like clusters, and the pedicels are longer. These latter specimens are so anomalous as to lead good observers to wonder if they are not hybrids with some cherry. I have not been able to observe any constant differences between these two types in foliage or fruit. I am disposed to regard these peculiarities as variations of one variety due to climate or some other local cause, for I find the same differences in other varieties grown here and in the south, as in Newman, Robinson and Marianna (Nos. 83, 86 and 92). I have examined a number of seedlings of Wild Goose at Mr. Kerr's, and while they differ from the parent in flavor and shape of fruit, they are much like it in general texture and character of fruit, the stones are singularly alike and the habits of the trees are similar; but in some of them the leaves tend to be irregularly toothed at the margins after the manner of the Wayland class. It should be said that the tree from which these seedlings were grown stood beside a tree of German Prune, but it is not known if these plants will hybridize.

The range of adaptability of the Wild Goose is great. It is hardy in central New York, and southern Michigan, and it succeeds well in Georgia and Texas. The tree resembles a peach tree.

62. *World Beater*.—Large, round-oblong, dark red, skin medium: cling; leaves medium and long-pointed, rather dull, somewhat irregularly serrate, the stalks usually glandular. Very late. Of good quality. Found wild in Tennessee. Introduced by Stark Bros. in 1889.

The Wild Goose type or group of plums, as a whole, appears to be best suited to the middle latitudes, being grown with satisfaction from Illinois and Indiana, and the southern part of Michi-

gan and New York to Maryland, Virginia and Tennessee, and in the southwest to Texas. The varieties which are most highly prized are Golden Beauty, Indian Chief, Missouri Apricot, Moreman, Wayland and Wild Goose.

C. THE MINER GROUP.—(*Prunus hortulana* var. *Mineri*). This group includes a few anomalous varieties which appear to be intermediate between *Prunus hortulana* and *P. Americana*. They may be an off-shoot of *P. hortulana*, or it is possible that they constitute a distinct species. The Miner is particularly well marked, but there are others which it is somewhat difficult to separate from *P. hortulana*. The group differs from the species by the dull and comparatively thick leaves which are conspicuously veiny below and irregularly coarsely toothed and more or less obovate in outline, by a late very firm fruit and by a more or less smooth and Americana-like stone. Fig. 4 is an excellent illustration of the under surface of a leaf of this group, and Fig. 5 shows the general habit. I am not able to designate the range of the wild plant, but it appears to occur in Illinois (and perhaps Indiana), Missouri, Tennessee, and perhaps in Arkansas.

63. *Clinton* (Fig. 4).—Fruit large, round, dull red, skin medium thick : cling, the stone short and broad and scarcely pointed,



FIG. 4.—Leaf of *Clinton*, full size.

nearly smooth ; flowers medium ; leaves (see cut) elliptic to elliptic-obovate, rather prominently pointed, the stalks glandular. Mid-

season, ripening several days before Miner. Thought by some to be the same as Miner, but the leaves, at least, appear to be different.

64. *Forest Rose*.—Large to very large, round, dull red, skin medium thick : stone cling, broad and comparatively flat, sharp on the front edge, scarcely pointed, smooth, Americana-like ;

flowers medium to large ; leaves elliptic to elliptic-obovate, prominently pointed, the stalks ordinarily bearing two small glands. Medium to late, of good quality. A Missouri wild variety, introduced by William Stark in 1878. C.

65. *Idol*.—Medium to rather large, round, bright light crimson splashed with magenta, skin thin : stone small, cling ; leaves obovate, the stalks glandular. Medium season. Said by D. B. Wier, the originator, to be very large, weighing as much as the average Lombard, but B. O. Curtis, Paris, Illinois, who now handles some of Wier's varieties, says that with him it is rather small and ripens the last of September and first of October. Said by Mr. Wier to be a cross between Miner and Wild Goose. Illinois.

66. *Indiana Red*.—Large, round, red : cling ; flowers medium ; leaves elliptic-ovate, prominently pointed, coarsely toothed, the stalks mostly prominently glandular. Medium to late. Said to have been an Indiana wild variety and to have been introduced by Dr. I. Cramer. By some thought to be the same as Miner. C.

67. *Iris*.—A medium red plum, with rather small and turgid stones which are scarcely pointed, and smooth or nearly so ; flowers medium ; leaves elliptic or elliptic-obovate, long-pointed, the stalks glandular. Illinois. D. B. Wier, originator and introducer. C.

68. *Langsdon* (Fig. 5).—Medium, round or round-oblong, light-red : stone cling, small and nearly smooth, turgid, very short-pointed ; leaves obovate or elliptic-obovate, moderately pointed, the glands small. Medium to late. Much like Miner.

69. *Leptune*.—Medium, round, dark-red, skin thick : cling, stone rather small and turgid, nearly smooth, short-pointed ; leaves elliptic-ovate to elliptic-obovate, very long-pointed and coarsely serrate, stalks either glandless or glandular. Late. Said to have been introduced by J. D. Morrow & Sons, Arkansas.

70. *Miner*.—Large, round or roundish-oblong, dull red, skin thick : stone cling, short and broad, smooth or very nearly so, very short-pointed, rather sharp on the front edge, Americana-like ; flowers medium to large ; leaves large and heavy, usually inclined to be obovate, rather long-pointed, the stalks glandular. Medium to late. Said by Downing* to have originated with Mr. Miner, Lancaster Co., Penn., but this is a mistake. The seed which produced the Miner plum was planted in 1814, in Knox County, Tennessee, by William Dodd, an officer under General Jackson. Dodd appears to have had two batches of seed, one

* Fruits and Fruit Trees, 2nd ed. 931.



FIG. 5.—Langsdon. $\frac{3}{4}$ full size.
(Fruits immature.)

lot this plum sprung. The plum gained some notice when it came into bearing, and was known as Old Hickory and General Jackson. In 1823 or 1824 Dodd moved to Illinois and settled near Springfield, taking some sprouts of his plum with him. The plums soon attracted attention among Dodd's neighbors, and the variety was called in its new home William Dodd and Chickasaw Chief. The year following William Dodd's removal to Illinois, his brother moved to Galena, Illinois, and took some of the plums. About Galena the plum became known as the Hinckley. I do not know how the name Miner came to be applied to it, but Downing's reference to Mr. Miner of Pennsylvania—who probably grew and disseminated it—undoubtedly explains it. It is said by D. B. Wier that the late Hon. James G. Souard, of Galena, gathered the year before upon Talaposa creek, and the other given him by an Indian chief. It is not clear from which

lena, introduced this plum to general cultivation, and I repeated this statement last year in a discussion of the Soulard crab.* (For a fuller history of the Miner, see A. Giddings in Iowa Agr. Rep. 1871, 332.) Downing gives Hinckley, Isabel, Gillett, Townsend and Robinson as synonyms of Miner. The Robinson now known is a very different fruit. (See No. 86.) The Miner is one of the best and most popular of the native plums, and is probably grown farther north with success than any other variety of this species (Groups B and C). In central New York it ripens in October. Colored plate in Agriculture of Pennsylvania, 1881. C.

Parsons.—Supposed to be identical with Miner, which see. C.

71. *Prairie Flower*.—A variety introduced by Stark Bros., Missouri; probably belongs in this group.

72. *Rachel*.—Medium, round-oblong, dull red, thick skin: stone cling, short and broad, thin-margined on the front edge, scarcely pointed, smooth, Americana-like; leaves long, elliptic-ovate, moderately pointed, stalks glandular. Medium to late. C.

The Miner group appears to be a strong and hardy race which is particularly adapted to the northern limits of the cultivation of the Hortulana family. The varieties are much alike. The Miner is the most popular member of the group, and it succeeds even in northern Illinois. In New York the varieties ripen from late September even to late October..

D. THE CHICKASAW GROUP.—(*Prunus angustifolia*, Marshall, *Arbustum Americanum*, III. [1785]. [*Prunus Chickasa*, Michx. Flor. Bor.-Am. i. 284.]). This group of plums differs from the Wild Goose group (B) by a more slender, spreading and zig-zag growth, usually smaller size of tree, red twigs, by smaller, lanceolate or oblong-lanceolate very closely serrate shining leaves which are conduplicate or trough-like in habit, by early small flowers which, upon old wood, are densely clustered on the spurs, and by an early red (rarely yellow) and more or less spotted translucent fruit, the flesh of which is soft, juicy, and more or less stringy and very tightly adherent to the small, broad, roughish stone. It is difficult to separate some of the cultivated forms of this species from small-leaved and weak-growing varieties of

* Amer. Garden, xii. 473.



FIG. 6.—*Newman*. Sprays half size. Leaf and stones full size.

Prunus hortulana, but the two species are easily separated in a wild state. The zigzag young twigs and trough-like leaves of the Chickasaws are characteristic, and are shown in Fig. 6. The leaves are often very small, scarcely exceeding an inch in length, but upon the more vigorous cultivated varieties, as the Newman, the leaf-blades are often three inches long and nearly flat. In herbarium specimens the species is usually recognized by the two halves of the leaves being pressed together so that the upper surface is hidden. In a wild state the trees or bushes are thorny, and the thorns persist in some of the cultivated varieties. It grows wild, often in dense thickets, from southern Delaware to Florida, and westward to Kansas and Texas. It is commonly stated in the books that the Chickasaw plum is not native to the Atlantic states, and some suppose that it was introduced into the United States from countries to the south of us. I have been unable to find sufficient reasons for these opinions, and I believe that the species is native to the southeastern states. In Maryland, as I have seen it, it behaves like an indigenous plant, and the people regard it as a true native. The small acerb fruit of the thorny and scraggly wild bushes is known in Maryland as "Mountain Cherry."

This species, like *Prunus Americana*, was founded by Humphrey Marshall in 1785. His description is as follows: "*Prunus angustifolia*. Chickasaw Plumb. This is scarcely of so large a growth as the former [*P. Americana*], but rising with a stiff, shrubby stalk, dividing into many branches, which are garnished with smooth lance-shaped leaves, much smaller and narrower than the first kind [*P. Americana*]; a little waved on their edges, marked with very fine, slight, coloured serratures, and of an equal, shining green colour, on both sides. The blossoms generally come out very thick, and are succeeded by oval, or often somewhat egg-shaped fruit, with a very thin skin, and soft, sweet pulp. There are varieties of this with yellow and crimson coloured fruit. These being natives of the southern states, are somewhat impatient of much cold."

73. *African*.—Medium to rather large, round-oblong, dark red; leaves small, short-oblong-lanceolate. Early to medium. Orig-

inated under cultivation by G. Onderdonk, S. Texas, and introduced by him in 1870. C.

74. *Arkansas Lombard*.—Medium, round or round-oblong, red; leaves medium, ovate-oblong. Early to medium, ripening just before Newman. Arkansas. Said to have been introduced by J. D. Morrow & Sons.

75. *Caddo Chief*.—Medium or rather small, round, red; leaves medium in size, short, ovate-oblong. Very early, ripening with Early Richmond cherry. Wild from Caddo Parish, Louisiana. Introduced by G. W. Stoner. Blooms and ripens very early. In northern Texas the fruit is ripe the middle of May. C.

76. *Coletta*.—Medium to large, round-oblong, light red; leaves small, oblong-lanceolate. Tree somewhat thorny. Early or very early. Originated under cultivation in southern Texas by G. Onderdonk, who introduced it in 1874. Ripens with Caddo Chief. C.

77. *Early Red*.—Medium, round, red; leaves medium, oblong-lanceolate. Early or very early. Origin southern Texas under cultivation by G. Onderdonk; introduced by him in 1872. There is a Russian plum (*Prunus domestica*), introduced by Professor Budd, known as Early Red. C.

78. *El Paso*.—Medium, round, red; leaves medium, ovate-oblong. Ripens during July and August in southern Texas. Originated and introduced by Lee Beaty, Texas.

79. *Emerson's Early*.—Rather large, round, purple-red, skin very thin: cling. Said to be a good market sort. Very early. Wild variety from northern Texas. Introduced by Mr. Bruce. Similar to Lone Star, but a better grower.

80. *Hoffman*.—Medium to rather large, round, purple-red; leaves medium, oblong-lanceolate. Mid-season to late. A wild variety from southwestern Missouri. "Very sure and prolific [in Texas]."—*Munson*. Ripe in northern Texas the middle of July, later than the Wild Goose.

81. *Jennie Lucas*.—Medium to rather large, round, yellow; leaves short, ovate-oblong. Early. Originated under cultivation and introduced, in 1875, by G. Onderdonk, southern Texas. C.

82. *Lone Star*.—Rather large, round-oblong, red, skin very thin; leaves rather small, oblong-lanceolate. Early. Originated in Texas by E. W. Kirkpatrick; grown from wild seed from eastern Texas. C.

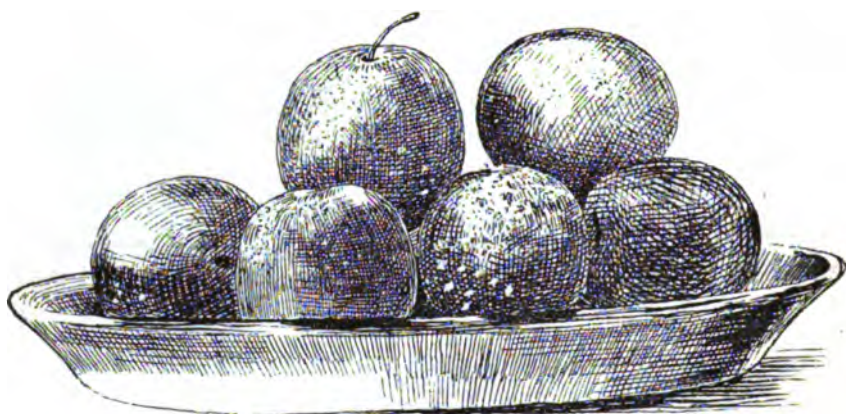


FIG. 7.—*Newman Plums. Natural size.*

83. *Newman* (Figs. 6 and 7).—Rather large, nearly globular or round-oblong, pink-red with prominent light spots near the apex, yellowish opposite the sun; leaves rather large, oblong-lanceolate. Medium to late. Ripens in New York in October. Introduced from Kentucky by W. F. Heikes. One of the best known of the Chickasaws. In our plantation the *Newman* is hardy, but the flowers, instead of appearing before the leaves as in the central and southern states, appear with the leaves in loose umbel-like clusters. This is the same kind of variation which occurs in the *Wild Goose* (see No. 61). In some of the New York trees the leaves are unusually large and often nearly plane. The Chickasaw method of growth is fairly well retained, however. *Warren* is thought to be identical with *Newman*. C.

84. *Ogeechee*.—Small to medium, round-oblong, red; leaves short, ovate-oblong. Very early. Similar to *Caddo Chief*. Wild from Georgia; introduced by G. Bourquin.

85. *Pottawattamie*.—Rather large, round, red; leaves rather small, narrowly oblong-lanceolate to ovate-oblong. Early to medium. Tennessee; it was taken to Iowa in a lot of Miners, and came under the notice of J. B. Rice, Council Bluffs, in 1875, who introduced it. Various stories are told about its origin, but the above is correct. It appears to have received its name from Mr. Rice. Like the *Newman*, the leaves appear to be larger in the north. "Enormous bearer."—*Berckmans*. C.

86. *Robinson*.—Medium, round, blotched red; leaves medium or small, ovate-oblong or oblong-lanceolate. Mid-season. "This is a seedling grown by a Mr. Pickett, of Putnam county, Indiana,

from a seedling brought with him from North Carolina, nearly fifty years ago, and has, almost every season (since large enough), borne abundant crops, but was neglected, and never brought to the notice of the public till 1879, when Dr. J. H. Robinson (of the same township) read a paper before the Indiana Horticultural Society, on Chickasaw Plums, and gave a very flattering description of this plum, which he had been watching since 1872, and of which he had two good crops on his own trees, which bore two bushels to the tree five years after planting, and has borne good crops annually, except once, when killed by late frosts. It was named by the Putnam County Horticultural Society in honor of Dr. Robinson."—Albertson & Hobbs, Bridgeport, Indiana (1885), who introduced the variety in the fall of 1884 and spring of 1885. Like Wild Goose and Newman, in New York the flowers appear with the leaves. C.

87. *Schley (Schley's Large Red)*.—Rather large, round, red; leaves medium, ovate or lance-ovate. Early to medium. Said to have been introduced from Georgia by W. K. Nelson. Much like Roulette except in foliage. Possibly *Prunus hortulana*. A very spreading and straggling grower. C.

88. *Strawberry*.—We are growing but have not fruited a plum under this name which appears to have been recently introduced. I know nothing of its history. C.

Warren.—See Newman.

89. *Wooten*.—Large, round-oblong, yellow with red markings; leaves medium, oblong-lanceolate. Medium to late. Found wild in central Texas (Colorado River), and introduced by A. M. Ramsey. "Very sure and prolific."—*Munson*. Ripe from early to middle July in northern Texas. Possibly *P. hortulana*.

90. *Yellow Transparent*.—Rather large, oblong, lemon yellow; leaves rather small, oblong-lanceolate. Early. Originated in northern Texas by J. L. Freeman. Selected from thousands of varieties grown from wild seed.

I have plants from Kansas under the name of "Kansas Dwarf Cherry," which are evidently a bush-like form of this species. They have not yet borne.

The "Sand Plum," which is occasionally grown in Nebraska, is *Prunus angustifolia*, if I may judge from leaves sent me by Dr. C. E. Bessey, of the University of Nebraska. Dr. Bessey writes as follows of this plum: * "Occasionally I hear of a 'Sand Plum,' said to grow in the southwestern and western parts of the state. No authentic specimens have been seen although I have in my

* Second Report upon Native Trees and Shrubs of Nebraska, 18.

collection some twigs and leaves from plants cultivated under this name, and thought, by the growers, to have been taken up from wild patches in the state." It is not improbable that this Sand Plum is the same as the Kansas Dwarf Cherry mentioned above.

The Chickasaw group is particularly adapted to the southern states and it succeeds as far north as Maryland and Kentucky, while some of the varieties are hardy in central New York. The leading varieties are Caddo Chief, Jennie Lucas, Lone Star, Newman, Pottawattamie, Robinson and Yellow Transparent.

E. THE MARIANNA GROUP.—The Marianna and De Caradeuc plums—and probably, also, the Hattie—constitute a distinct class from any of the foregoing, differing in habit of tree, very early flowering, elliptic-ovate rather small and finely serrate dull leaves, glandless leaf-stalks, and soft spherical, very juicy plums of a "sugar and water" character, and broad ovate stones which are scarcely pointed and are prominently furrowed on the front edge. The botanical position of these plums has been a subject of speculation, to which I have added my full share of confusion.* I have devoted more study to these plums than to any others, and I am now convinced that the De Caradeuc is myrobalan and that the Marianna is either the same species or a hybrid between it and some American plum, possibly the Wild Goose. This, I am aware, is a startling conclusion, particularly as the Marianna has come to be so extensively used as a stock to replace the myrobalan, which appears to be growing in disfavor. Before entering into detail concerning the origins of these plums, it will be useful to our inquiry to clear up some of the history of the myrobalan plum.

The word myrobalan (or myrobolan), as a noun, is used to designate various small tropical fruits which are used in the arts, chiefly for tanning purposes. It is now commonly applied to the fruits of the species of *Terminalia*, of the family *Combretaceæ*, which are imported from India. The word was early applied to a small plum grown in Europe, probably because of some resemblance in size or other characteristics to the myrobalans of commerce. This plum has had a curious history. The first un-

* In my Nursery-Book (p. 252) I referred them to *Prunus umbellata*, Ell.

doubted reference to it which I know is in Clusius' *Rariorum Plantarum Historia*, 1601. Clusius gives a good figure of it, but says that it was not generally known. Some people thought that it came originally from Constantinople, and others that it came from Gaul. Clusius leans toward the latter view. He calls it the myrobalan plum, but does not know the origin of the name. For nearly two hundred years after Clusius wrote, the fruit is described by various authors in different parts of Europe, under the names of myrobalan or cherry plum, during which time doubts were cast upon its European origin. Thus Tournefort in 1700 said that it came from North America. In 1789 Ehrhart* described it as a distinct species under the name *Prunus cerasifera* or "cherry-bearing plum," and said distinctly that it is a native of North America. Some thirty years before this time, Linnæus had described it as *Prunus domestica* var. *myrobalan* and gave it a European origin. In 1812, Loiseleur Deslonchamps† described it as *Prunus myrobalana*, saying that it was supposed to be of American origin. From that time until now the nativity of the myrobalan plum has been uncertain, but European writers have usually avoided the difficulty by referring it to America; and American botanists have for the most part ignored it because it is a cultivated plant. So it happens that this pretty fruit has fallen between two countries, and is homeless. Sereno Watson in his Index to North American botany published in 1878, refers Ehrhart's *Prunus cerasifera* to the common beach plum (*Prunus maritima*) of the Atlantic coast. But the myrobalan is wholly different in every character from the beach plum, and it has been long cultivated upon walls in Europe, a treatment which no one would be likely to give to the little beach plum. Torrey and Gray in 1838, in the Flora of North America, do not mention the myrobalan plum. After all the exploration of the North American flora, no plant has been found which could have been the original of this plum; while its early cultivation in Europe, together with the testimony of Clusius and other early herbalists, is strong presumption that it is native to the Old World. This presumption

*Beiträge zur Naturkunde, iv. 17.

†Nouveau Duhamel Traité des Arbres et Arbustes, v. 184, t. 57, fig. 1.

is increased by the doubt which exists in the minds of the leading botanists, from Linnæus down, as to its systematic position, for if there is difficulty in separating it from *Prunus domestica*, the original of the common plum and which is itself a native of the Old World and immensely variable, there is strong reason for suspecting that it is only an offshoot of that species ; and this presumption finds strong support in other directions. But one need not study far into the European plums until he convinces himself that the essential features of the myrobalan plum are present in several of the wild or half wild forms of southern and southeastern Europe, no matter what the ultimate origin of the fruit may be. Plums from Turkestan (presumably wild) now growing upon the grounds of Ellwanger & Barry at Rochester, N. Y., are certainly myrobalan ; and it may be said that the so-called *Prunus Pissardi*, which has been recently introduced from Persia, is but a purple-leaved myrobalan plum.* I have no doubt, therefore, but that the myrobalan plum is native to Europe or Asia ; and it is full time that an America origin be no longer ascribed to it.†

The myrobalan plum has long been used in this country as a stock for various plums. Except upon the Pacific coast, it appears to be falling into disuse, however, as it dwarfs the cion and is not suited to all varieties. The endeavor to find some stock which can take the place of the myrobalan has resulted in the popularizing of the Marianna, but which, if not pure myrobalan, certainly partakes very largely of it. The myrobalan is generally distributed over the country as a stock, and bearing trees of it are occasionally seen. The Golden Cherry plum of Downing‡ is undoubtedly this species, and the fruit now known as Youngken's Golden Cherry is certainly myrobalan, and it is probably identical with the variety described by Downing. The fruits may be either yellow or red in various shades. They are round and cherry-like, with a depression at the base, on slender stems, ranging in size from that of a large cherry to an inch and a half in diameter. The myrobalan is very variable, a fact which finds

*Mr. Kerr has grown a purple-leaved plum from seed of De Caradeuc.

† See also Garden and Forest, i. 178.

‡ Fruits and Fruit Trees, 916.



FIG. 8.—*Marianna*. Sprays half size. Details full size.

record in the various shapes and sizes of the commercial imported stones.

91.—*De Caradeuc*.—Rather large (1 to $1\frac{1}{4}$ in diam.), globular, deep dull purple red when ripe with a prominently colored suture, but yellowish green splashed with red when it first becomes edible: flesh thin, very juicy and sweet: cling, the stone round-ovate, rather turgid, scarcely pointed and evenly pitted; leaves rather firm, ovate-oblong. Early. In central New York it ripens from the first to the middle of August. Tree an erect grower. This plum appears to agree with the myrobalan in all important botanical characters, even to the broad and strongly reflexed calyx lobes and stalked flowers. About a year ago I became convinced that De Caradeuc is *Prunus cerasifera*, and I was glad to have my opinion confirmed by so good a nurseryman as P. J. Berckmans of Georgia, who named the variety; and the origin of the plum, which I have since learned, corroborates my conclusion. It originated with A. De Caradeuc upon his former farm near Aiken, South Carolina, about the years 1850 to 1854. Mr. DeCaradeuc imported some French plums, from the seed of which this variety came. There were several Chickasaw plums in the vicinity of the French trees and Mr. DeCaradeuc thinks that the variety under consideration is a hybrid, but I am unable to discover any evidence of hybridity. The original tree of the variety "outgrew the parent, and reached a diameter of head of fifteen feet, was entirely free from thorns and suckers, and bore a remarkably rich and beautiful foliage." The variety blooms very early, some days ahead of the Marianna, and the flowers, as in all varieties of *P. cerasifera*, are somewhat scattered and less abundant than in the native species. C.

92. *Marianna*. (Fig. 8).—Large, round-oblong, short-stemmed as compared with the De Caradeuc, bright red and finely speckled and covered with a thin bloom: flesh soft and sweet, juicy: semi-cling, the stone like that of DeCaradeuc (see Fig. 8); flowers small, sessile or short-stalked, in dense lateral clusters like the native varieties, the calyx lobes, narrow and erect; leaves much as in De Caradeuc, but thinner. A little later than De Caradeuc, but ripens before the Wild Goose. Tree a very spreading grower. C.

From the above description it will be seen that the Marianna is in several respects intermediate between *Prunus cerasifera* as represented in DeCaradeuc, and the native American plums, particularly in the short-stemmed fruit, small nearly sessile and clustered later flowers and erect narrow calyx lobes, and spreading habit. It is therefore little surprise to learn that the originator considers it a seedling of Wild Goose. It originated as a seedling in a

mixed orchard at Marianna, Polk Co., Texas, the property of Charles G. Fitzè. So far as I can learn, the seed was not hand-sown, and there is a chance for error in the history. The variety was introduced in 1884 by Charles N. Eley, Smith Point, Texas.

The Marianna grows readily from cuttings, and this, in connection with the hardiness and vigor of the variety and the readiness with which it unites in graftage with several species of prunus, has made it very popular as a stock. The myrobalan itself grows from cuttings but in most cases not to a profitable extent. I have recently made a small experiment upon the rooting of cuttings of myrobalan, De Caradeuc and Marianna in identical conditions, under heat. Of myrobalan cuttings, less than ten per cent. grew; of De Caradeuc, less than twenty per cent.; of Marianna, about seventy per cent. I do not know where the Marianna could have obtained this peculiarity to grow readily from cuttings; but it is idle to attribute it to hybridity until we have determined if all varieties of myrobalans grow with equal difficulty from cuttings. The question will at once arise if the Marianna is reliable as a stock, seeing that it is probably partly of myrobalan origin; and in reply I can only say that experience alone can determine the value of a stock. Thus far the Marianna has given good results. I apprehend that some of the dissatisfaction with myrobalan stocks should be laid to the indiscriminate use of variable seedlings; in order to obtain uniform results a particular variety or strain of myrobalan should be used. In this connection I may observe that the flowers of Marianna appear with the leaves in New York, while they appear before the leaves—as shown in Fig. 8—in the middle and southern states; and this peculiarity I have observed in myrobalan, and also, as previously recorded, in Wild Goose, Newman and Robinson.

93. *Hattie*.—Medium, round-oblong, red: cling, the stone much like that of Marianna in shape but rather more pointed and nearly smooth; flowers small and clustered, the calyx lobes small and erect; leaves small, short-oblong or ovate-oblong, somewhat conduplicate, dull and firm, finely serrate, the stalks glandless; branches stiff and conspicuously rough or warty. Early, below medium in quality. The history of this plum I am unable to trace. In some respects it closely resembles the Chickasaws, but I cannot escape the conviction that it is partly myrobalan. I have seen the same rough shoots in the myrobalan plum. C.

F. THE BEACH PLUM.—(*Prunus maritima*, Wangenheim [1781]). Fig. 9. The beach plum is a straggling more or less decumbent bush, reaching three to six or even twelve feet in height, growing in the sands of the sea-coast from New Brunswick to Virginia, and perhaps extending farther towards the southwest.* The flowers are rather large for the size of the plant, and are borne on prominent stalks in clusters. The fruit, in the best forms, is about a half inch in diameter (see Fig. 9), and is deep, dull purple when ripe, and covered with a dense bloom; the flesh is brittle, sweet and juicy, entirely free from the stone; the skin is thick and tough, and usually leaves an acrid taste in the mouth when the fruit is eaten. Upon the Jersey coast the fruit is ripe the middle of August. *Prunus maritima* is in cultivation as an ornamental plant, it being very showy when in bloom and interesting in fruit. It succeeds well under cultivation in the interior states. As a fruit plant it has given rise to but one variety:

94. *Bassett's American* (Fig. 10).—Small (about $\frac{3}{4}$ in. in diameter), round or slightly round oblate, dull red, skin medium thick: free-stone, the stone nearly circular in outline with a very short point or even pointless, thin upon the front edge, slightly rough; leaves a fourth or third larger than those of the wild beach plum. Medium to late, ripening in late August in eastern Maryland. Quality poor. Introduced about 20 years ago by Wm. F. Bassett, Hammonton, N. J., who bought the original tree of a man who found it in the neighborhood. It works well upon the Wild Goose, and Mr. Bassett writes me that he has a tree on such roots which is fifteen feet high. It was largely brought to notice through the efforts of the Rumson nurseries, where it was worked upon the myrobalan plum and the peach. I

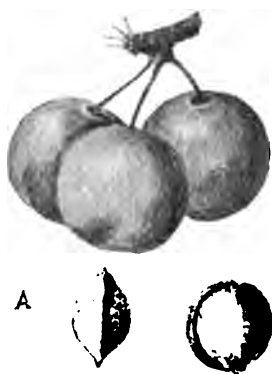


FIG. 10.—*Bassett's American*.
Full size.

have seen a vigorous large tree at Mr. Kerr's grafted upon the Richland, which is *Prunus domestica*. Mr. Kerr also finds that it grows upon the Chickasaws. The variety appears to differ from the wild beach plum only in size.

G. *PRUNUS SUBCORDATA*, the wild plum of the Pacific coast,

* *Prunus maritima* has been found recently near the head of Lake Michigan. It is supposed to have been introduced.



FIG. 9.—*Beach Plum* (*Prunus maritima*). Sprays half size. Details full size.

was introduced to cultivation in 1889 by T. V. Munson (see *Annals Hort.* 1889, 104 ; 1891, 235). It is a straggling much branched shrub growing from three to ten feet high. It has subcordate roundish or round-ovate tomentose leaves and large pedicelled flowers which appear with the leaves. The red fruit reaches three-fourths inch long. It is eaten by Indians and whites. Its value in cultivation is yet to be determined.

2. H. HYBRIDS.—It is not known to what extent the native species of plums hybridize with each other or with foreign species, and nearly all the definite attempts at crossing are so recent that results have not been obtained. The only apparently authentic hybrids have come from the union of the Wild Goose and the peach. Mr. Kerr has what appears to be an undoubted hybrid. The tree, as I recall it, is large, spreading and peach-like. The leaves are long and peach-like, although rather broad and short-pointed, but the flower buds, although they form in profusion, never open, so that the tree is barren. This is a hybrid between the Wild Goose and Troth's Early peach. Twenty-five flowers of Wild Goose were emasculated in the bud and covered with paper sacks. When in full bloom, peach pollen was applied, but the flowers were not again covered. Twenty-one of the flowers set fruit, and twenty-one trees were obtained from the seeds. Twenty of the trees were indistinguishable from peach, but the remaining one, as indicated above, gives every evidence of being a hybrid. One other apparent hybrid is the

95. *Blackman*.—Nearly thirty years ago Mrs. Charity Clark procured from an orchard in Rutherford Co., Tenn., which contained Wild Goose and Washington plums, seeds of plums and gave them to Dr. Blackman, of Nashville. One tree among the resulting seedlings bore good fruit and it was called the Blackman, and was disseminated by a local nurseryman. A competing nursery, in endeavoring to procure cions from this tree, inadvertently cut them from an adjacent tree—itsself one of the batch of seedlings—and sold the trees which it grew as Blackman. Now this second tree makes fruit buds in abundance but they never open ; and from the resemblance of the leaves to those of the peach the plant is generally thought to be a hybrid between the Wild Goose and the peach. This assumption finds partial confirmation in the experiments of Mr. Kerr, recorded above, for this spurious Blackman is very much like his hybrid although the leaves are more pointed and still more peach-like. Curiously enough, the genuine Blackman has never been widely dissem-

aunted, but the spurious and worthless substitute has been sold in large quantities. In order to avoid confusion, the original Blackman has been rechristened Charity Clark. There are therefore, two Blackman plums, one of which is practically unknown to cultivation, but which has been renamed, and the other is barren and will soon pass from sight.* C.

I. UNCLASSIFIED VARIETIES.—The following varieties I know only from printed references or from information afforded by correspondents, and I cannot, therefore, refer them to their proper species.

96. *Allen's Yellow*.—Medium, round, yellow and red, skin thick : cling. Kansas.

97. *Berry*.

98. *Champion*.—Very large, oblong, dark red, thick skin : flesh firm : cling. Late. H. A. Terry, 1890. Originated under cultivation.

99. *Charles Downing*.—Large, round-oblong, red, skin thin : flesh firm : cling. Medium to late. Should be worked on peach. H. A. Terry, Iowa, 1885. Originated under cultivation.

100. *Cherokee*.—A medium size plum, round-oblong, blotched red, thick skin : cling. Said to have been found wild in Kansas.

101. *Col. Wilder*.—Large round-oblong, red, thin skin : flesh firm and of best quality : cling. Medium to late. H. A. Terry, Iowa, 1888. Originated under cultivation.

102. *Cook's Choice*. Medium, round, red, thin skin : flesh of best culinary quality : cling. Medium to late. H. A. Terry, 1885. Originated under cultivation.

103. *Couler*.—From Wm. Couler, Chickasaw Co., Iowa. "The Couler is a large plum of fair quality, ripening a little before Miner, but sometimes cracks open badly before ripe."—O. H. Kenyon McGregor, *Iowa Hort. Rept. xvii. 235*.

104. *Crescent City*.—Rather large, oblong, dark red, skin thick : cling. Late. H. A. Terry, Iowa, 1885. Originated under cultivation.

105. *Diamond*.—Seedling from wild Nebraska seed grown by John A. Hogg. "Grows fully as large as most of the tame varieties. Ripens last of September, and when fully ripe gets bright red on one side."—John A. Hogg, *Nebr. Hort. Rept. 1890, 121*.

106. *Dr. Dennis*.—Large, round-oblong, red, thin skin : flesh

*For a fuller account of the Blackman plums, see VanDeman in Rept. Dept. Agric. 1887, 636. The Blackman has been recommended as a stock for peaches upon the supposition that it enjoys immunity from yellows. See Cal. Orchard and Farm, iv. 3.

firm and good : cling. H. A. Terry, Iowa, 1890. Originated under cultivation.

107. *Dunlap*.—Large, round, yellow, thin skin : flesh firm and of high quality : cling. Medium season. Nebraska seedling introduced by J. P. Dunlap.

108. *Early Honey*.—An early variety, evidently a Chickasaw, which originated in Grayson Co., Texas.

109. *Ellis*.—Rather large, round, red, skin very thin : semi-cling. Ranks high for market or for home use. Late. Said to be a cross between Wild Goose and Golden Beauty. N. Texas. Introduced by T. L. Ellis.

110. *Esther*. Rather large, round-oblong, dark red, skin thick : cling. Medium to late. H. A. Terry, Iowa, 1885. Originated under cultivation.

111. *Excelsior*.

112. *Hammer*.—Large, oblong, light red, skin thin : of extra quality : cling. Medium to late. H. A. Terry, Iowa, 1888. Originated under cultivation. Said to be a seedling of Wild Goose.

113. *Houston County*.

114. *Hughes*. A large round red plum said to have come from northern Mississippi.

115. *Iola*.—Very large, oblong, dark yellow and red, skin medium thick : flesh firm : free. Late. D. B. Wier, Illinois.

116. *Irene*.—Very large, round, bright red, thick skin : flesh firm : cling. Late. D. B. Wier, Illinois.

117. *Ithaca*.—Said to have come from Peter M. Gideon, Minn.

118. *James Vick*.

119. *Jewell*.

120. *Jones*.—Large, oblong, red, skin thick : flesh firm, good : cling. Late. H. Jones, Iowa, 1882. Originated under cultivation.

121. *Miles*.—Said to have originated in Illinois from seed taken from North Carolina.

122. *Milton*.—Rather large, round-oblong, dark red, skin thin : flesh firm : cling. Early. H. A. Terry, 1885. Said to be a seedling of Wild Goose.

123. *Mrs. Clifford*.—Very large, pear-shaped, red, skin very thin : semi-cling. Fine for market or home use. Possesses a peculiar and agreeable pineapple flavor. Medium early. Originated in northern Texas under cultivation, and introduced by E. C. Clifford. Said to be a seedling of Wild Goose, and a great improvement upon that variety.

124. *Muncy*.
 125. *Munson*.—Rather large, oblong, red, skin thin : cling. Late. Originated under cultivation in Texas. Introduced in 1888 by G. Onderdonk.
 126. *New American*.
 127. *Okaw*. (Annals Hort. 1890, 175).
 128. *Piram*.—Large, round, yellow, skin thin : cling. Medium early. A very productive variety. Originated under cultivation in Texas and introduced by G. Onderdonk.
 129. *Rare Ripe*.—A dark red plum a little smaller than De Soto : cling. Quality better than De Soto, but inferior to Harrison's Peach. Hardy.—C. A. Keffer, Bull. 26, S. Dak. Exp. Sta.
 130. *Raymond*.
 131. *Rockford*.—Good size, round, purple, thin skin : of best quality : cling. Medium to late. Wild Iowa variety, introduced by C. G. Patten, Charles City Iowa, 1889. C.
 132. *Rocky Mountain Seedling*.
 133. *Round*.—From Iowa.
 134. *Silas Wilson*.—Large, round-oblong, light red, skin thin : of best quality : cling. Medium to late. H. A. Terry, Iowa, 1890. Originated under cultivation.
 135. *Smiley*.—Very large, dark red. Alabama?
 136. *Tenneha*.
 137. *Tomlingson*.
 138. *Van Deman*.—Large, round, light red, skin thin : of best quality : cling. Medium to late. H. A. Terry, Iowa, 1890. Originated under cultivation.
 139. *Wady's Early*.—Early and very good, but the tree is a poor grower and the fruit is rather small.
 140. *Winnebago*.—Fruit above medium in size, orange-scarlet, excellent for culinary purposes. Minnesota. Probably *P. Americana*.

§ 2. *Cultivation of the Native Plums.*

1. *Impotent varieties. Planting*.—It is not strange that difficulties should beset the cultivation of fruits which are yet scarcely rescued from a wild state. The chief difficulty in the growing of the native plums is the fact that some varieties do not fertilize themselves. This peculiarity appears to be due not to any imperfection in the flowers but to the comparative impotency of pollen upon flowers of the same variety. Imperfect flowers are occasionally observed, but they are apparently peculiarities of individual trees or particular seasons. Thus in our Newmans

this year only about every twelfth flower has a perfect pistil. I have observed a similar defect in wild plums. I know a wild tree of *Prunus Americana* which bears flowers without pistils. The impotency of pollen appears to be characteristic of certain varieties, as, for example, Wild Goose, Miner, Wazata, Minnetonka, Itaska. Other varieties of the same species are fertile with themselves, as Moreman, Newman, Wayland, Golden Beauty, Marianna, Deep Creek, Purple Yosemite. In order to insure fertilization, mixed planting is practiced when the impotent varieties are grown; and it is an important study to determine what varieties are the best pollinizers for a given kind. Evidently, the two varieties in any case must bloom at the same time and the pollinizer must produce an abundance of pollen. Thus the Newman is a good pollinizer for the Wild Goose, but it blooms too early for the Americana varieties. In some of the western states, Forest Garden is considered to be a good pollinizer for Miner. It is a common opinion among good plum growers that the common or *Domestica* plums, the peach and even the cherries will fertilize the Wild Goose. There is certainly much general evidence in support of this opinion, but it remains to be proved. A case within my own experience lends color to this opinion. A half dozen large trees of Wild Goose were barren until trees of plums and cherries about them bloomed profusely, when the Wild Goose bore a heavy crop.

There is much difference of opinion concerning the methods of planting in order to secure fertilization. Many growers advise planting in thick hedge-like rows, the trees standing not more than four or eight feet apart in the row, every fourth or fifth tree, or every alternate row, being a self-fertile and very polliniferous variety. Others practice setting the trees from nine to twelve feet apart each way, with the impotent varieties in alternate rows. In this way, for example, Forest Garden is made to fertilize both Miner and Wild Goose. This treatment is commonly known as "close planting," and it has many able advocates. It is said, also, that this close planting shades the ground so completely as to make it too cool for the rapid development of the curculio. Such plantings, unless the trees are heroically trimmed, soon result in an unmanageable tangle. I have seen a Wild Goose tree 36 feet across and still growing and bearing, and Miner, Leptune and

Langsdon scarcely less. Mr. Kerr, who is a very successful grower, sets his trees from twenty to thirty feet apart, and others have good success with equally thin planting. It is probable that different varieties or combinations demand different treatment in this respect; but it is plain that while the majority of native plums appear to be self-fertile, some of the most important varieties are impotent.

2. *Propagation*.—Another important difficulty is that relating to the selection of stocks. The native species work well upon each other, but the permanency and strength of the different unions are still moot points. The varieties also unite readily with the Marianna; and *Domestica* plum stocks, myrobalan and peach are also used. In general, it may be said that a variety prefers a stock of its own species, although the true Chickasaws sprout or sucker so badly as to make them undesirable. In the northern states, especially in the prairie region, the *Prunus Americana* stocks are most reliable because of their hardiness; and as the *Americana* varieties are the ones chiefly grown in this region, the problem is a comparatively simple one. Wild Goose is grown largely upon the peach in the warmer latitudes and some growers prefer this stock even in the north. All the Chickasaws grow well upon the peach, as do also Miner, Forest Rose, and perhaps all the *Hortulana* type. Recently the Marianna has come to be a popular stock upon which to work all varieties; and as far as known it is one of the best, although I fear that its indiscriminate use may result in some disappointment. Mr. G. Onderdonk, a well known nurseryman and fruit grower of Texas, is certain that the Marianna is preferable to the peach as a stock for the southern native plums. His reasons for this opinion are as follows:*

“1st: The peach sometimes sprouts from the roots. The Marianna never does this.

“2d. The peach has more eyes or buds near the surface of the soil, both above and below, than the Marianna. These eyes cause at least two or three times more pruning in the case of peach stocks than in Marianna.

“3d. The peach requires better drainage than the plum stock.

*Fruit Growers' Journal.

I raise good healthy plum trees on Marianna stocks in places where it would be useless to plant anything on peach stocks.

"4th. The peach stock is subject, under certain conditions, to root-rot. I have never seen a case of root-rot among Mariannas.

"5th. While the Marianna is subject to root-knot as well as the peach, yet it very seldom fails to have the knot at the bottom, so that it can be cut away without injury to tree. In case of peach stocks the tree is usually lost when infested with root-knot.

"6th. In extreme southern Texas peach seeds fail to germinate either totally or partially after a mild winter. In the spring of 1890, not a single peach seed germinated in this section. We have much annoyance from this source. On the contrary we have never failed of securing a good stand of Marianna plants from cuttings, when they had been properly treated. Therefore the Marianna makes us a sure supply of stocks for propagation of plum trees, which the peach does not do in southern Texas. Farther north these conditions may be less worthy of consideration.

"7th. As each peach seedling is a distinct variety from every other one, and the different varieties vary materially in vigor, and often in other habits, it follows that the stocks necessarily vary in capacity to develop trees. On the other hand a reasonable amount of care in selecting cuttings of the Marianna enables us to produce stocks of nearly uniform capacity, and therefore to produce trees of a more nearly uniform strength and value."

These comparisons will hold, Mr. Onderdonk thinks, in reference to stocks for apricots, but for peaches the Marianna is a failure with him.

Sprouts from own-rooted trees are often employed for increasing native plums, of such varieties as sprout readily, as Miner, Wild Goose, Forest Garden, De Soto and various Chickasaws. But this practice is not in general favor.

3. *Varieties.*—The question of the best varieties for certain purposes and regions is a disputed one, as should be expected from the large number of varieties in cultivation and the newness of the native plum industry. Undoubtedly the most popular variety is the Wild Goose, but its popularity is due less to the quality of its fruits than to the hardiness and productiveness of the tree and the early fruit. The Miner is perhaps the hardest

well-known variety of the *Hortulana* type. It succeeds in many places in northern Illinois. In Wisconsin, Iowa, Nebraska, and regions to the north of them, only the *Americana* class is hardy, as a rule. The Chickasaws are best adapted to the middle and southern states. None of the native plums have been tried to any extent in New York and New England, from the fact that the common or *Domestica* plums succeed so well there. The incursions of the septoria or shot-hole fungus,—which causes premature dropping of the leaves,—are calling attention to the native plums, and it is not too much to expect that they will gain in favor as they become better known. And the growing taste for a greater variety of fruits must tend to popularize some of the native plums in the east.

In order to determine the values of the leading varieties in different parts of the country, I have obtained the opinions of various representative growers, and these estimates are tabulated below. Two estimates have been asked for each variety, one upon its market value as judged by productiveness and vigor of tree and size, beauty and firmness of fruit, and one upon its home value as a culinary or dessert fruit. The estimates are expressed in figures, 10 being taken to represent the highest excellence. The figures in the first double column were compiled by myself and were sent to all the correspondents, who marked their disagreements from my estimate. In general, therefore, it may be said that when a correspondent gives no estimate he agrees with my own; although there are some varieties in each case with which the correspondent was not acquainted, and he should not be held to a strict account for the unreported varieties. Finally, I wish to say that my own estimates are made very largely upon the judgments of Mr. Kerr, of the Chesapeake peninsula (Maryland), and that all my figures will apply to that region.

TABLE I.—HOME AND MARKET VALUES OF NATIVE PLUMS.

No. in preceding lists.	Variety.	Species.	Kerr, Md. S. Gordon, N. J.		Onderdonk, Tex.		Stark, Mo.		Carpenter, Neb.		Terry, Ia.		Wier, Ill.		Lord, Minn.	
			Home.	Market.	Home.	Market.	Home.	Market.	Home.	Market.	Home.	Market.	Home.	Market.	Home.	Market.
73	African.....	angustifolia.....	5	8	8	8										
74	Ark'nsas Lombard.....	angustifolia.....	5	5												
75	Caddo Chief.....	angustifolia.....	4	5			1	0							10	10
5	Cheney.....	Americana.....	8	10												
63	Clinton.....	hortulana var.....	7	8												
76	Coletta.....	angustifolia.....	5	7												
47	Cumberland.....	hortulana.....	5	7												
91	De Caradenc.....	cerasifera?.....	7	10												
8	Deep Creek.....	Americana.....	8	10												
9	De Soto.....	Americana.....	8	10			10								10	10
77	Early Red.....	angustifolia.....	4	5			10									
10	Forest Garden.....	Americana.....	7	8			1	0							5	5
64	Forest Rose.....	hortulana var.....	7	8			1	5								
48	Garfield.....	hortulana.....	9	10			10	10								
49	Golden Beauty.....	hortulana.....	9	10			10	5								
12	Harrison's Peach.....	Americana.....	8	8												
93	Hattie.....	?	4	6												
13	Hawkeye.....	Americana.....	8	10											5	5
66	Indiana Red.....	hortulana var.....	8	7			5								8	10
50	Indian Chief.....	hortulana.....	5	10					7	9						
17	Itaska.....	Americana.....	7	7												
81	Jennie Lucas.....	angustifolia.....	5	8			1	0								
18	Kickapoo.....	Americana.....	8	8												

[illegible]

TABLE II. SUCCESSION OF PLUMS ON THE CHESAPEAKE PENINSULA. (KERR).

Very Early.	Early.	Medium Early.	Medium.	Medium Late.	Late.
Caddo Chief (75) Early Red (77) De Caradeuc (91)	Marianna (92) Yellow Transparent (90) Jennie Lucas (81) Hattie (93) Lone Star (82)	Newman (83) (<i>Warren</i>)	Schley (87) Indian Chief (50) Wild Goose (61)	Roulette (56) Robinson (86) Cumberland (47) Ark. Lombard (74) Wazata (38) Itaska (17) Minnetonka (27) Deep Creek (8) Pottawattamie (85)	Wayland (59) Moreman (53) Wolf (42) Rollingstone (35) Kickapoo (18) Missouri Apricot (52) Purple Yosemite (33) Miner (70) Clinton (63) Leptune (69) Reed (55) Quaker (34) De Soto (9) Forest Rose (64) Forest Garden (10) Golden Beauty (49) Indiana Red (66) Louisa (23) Garfield (48) Van Buren (37) Hawkeye (13) Harrison's Peach (12) Cheney (5)

The figures in parentheses are the numbers attached to the varieties in the preceding lists.

I am indebted to Mr. Kerr, of Maryland, for some very accurate and interesting observations concerning the seasons of leading native plums and the dates of blooming. Tables II, III and IV contain this information :

TABLE III. ACTUAL DATES OF RIPENING OF NATIVE PLUMS ON THE CHESAPEAKE PENINSULA (KERR).

73	African	From July 20-Aug.	20
74	Arkansas Lombard.....	" 30- "	25
75	Caddo Chief.....	" 6-July	20
76	Coletta	" 20-Aug.	15
47	Cumberland.....	Aug. 1-	25
91	De Caradeuc	July 15-	10
8	Deep Creek.....	" 20- "	15
9	De Soto.....	" 25- "	20
77	Early Red.....	" 6-July	20
10	Forest Garden.....	" 25-Aug.	20
64	Forest Rose.....	" 20- "	20
48	Garfield.....	Sept. 1-Oct.	10
49	Golden Beauty	Aug. 20-Sept.	15
93	Hattie.....	July 25-Aug	15
66	Indiana Red.....	" 25- "	20
50	Indian Chief.....	" 20- "	5
17	Itaska.....	Aug. 1- "	25
81	Jennis Lucas.....	July 12-July	25
18	Kickapoo.....	" 25-Aug.	15
69	Leptune.....	Aug. 25-Sept.	30
82	Lone Star.....	July 8-July	25
23	Louisa	" 25-Aug.	20
92	Marianna	" 8- "	1
70	Miner.....	" 25- "	25
27	Minnetonka	Aug. 1- "	25
52	Missouri Apricot.....	Sept. 1-Sept.	25
53	Moreman	Aug. 25- "	30
83	Newman	July 30-Aug.	30
85	Pottawattamie	" 30- "	25
33	Purple Yosemite.....	" 25- "	20
34	Quaker.....	" 25- "	20
55	Reed.....	Aug. 25-Sept.	30
86	Robinson.....	July 30-Aug.	20
35	Rollingstone.....	" 25- "	20
56	Roulette.....	Aug. 1- "	20
87	Schley	" 5- "	25
59	Wayland.....	Sept. 1-Oct.	5

38	Wazata.....	Aug. 1-Aug. 20
39	Weaver.....	July 25- " 25
61	Wild Goose.....	" 10-July 30
		or sometimes to Aug. 10
42	Wolf.....	July 25- " 25

Mr. Kerr has made a careful record of the periods of flowering of the native plums for this year,—which was unusually late,—and it is given below :

TABLE IV. FLOWERING PERIODS OF NATIVE PLUMS
ON THE CHESAPEAKE PENINSULA FOR 1892 (KERR.)

	First flowers open.	Half the flowers open.	All open.
73 African.....	April 19	April 25	April 27
1 American Eagle.....	" 29	" 30	May 1
74 Arkansas Lombard.....	" 23	" 26	April 28
94 Bassett's American.....	" 30	May 1	May 2
75 Caddo Chief.....	" 14	April 16	April 20
63 Clinton.....	" 27	" 29	May 1
76 Coletta.....	" 15	" 19	April 23
47 Cumberland.....	" 23	" 26	" 28
91 De Caradeuc.....	" 5	" 9	" 14
8 Deep Creek.....	" 23	" 24	" 26
9 De Soto.....	" 25	" 28	" 30
77 Early Red.....	" 14	" 16	" 20
10 Forest Garden.....	" 27	" 28	" 30
64 Forest Rose.....	" 27	" 29	" 30
48 Garfield.....	" 26	" 28	" 30
49 Golden Beauty.....	" 28	May 1	May 3
12 Harrison's Peach.....	" 27	April 28	April 29
93 Hattie.....	" 15	" 17	" 19
13 Hawkeye.....	" 27	" 29	May 1
66 Indiana Red.....	" 27	" 29	April 30
50 Indian Chief.....	" 25	" 27	" 29
67 Iris.....	" 26	" 29	May 1
17 Itaska.....	" 14	" 16	April 19
81 Jennie Lucas.....	" 14	" 22	" 25
18 Kickapoo.....	" 23	" 25	" 28
31 Le Duc.....	" 27	" 29	" 30
69 Leptune.....	" 27	" 30	May 1
82 Lone Star.....	" 20	" 25	April 28
23 Louisa.....	" 25	" 27	" 29
91 Marianna.....	" 7	" 15	" 19
70 Miner ...	" 25	" 27	" 29
27 Minnetonka.....	" 23	" 25	" 27

52	Missouri Apricot.....	"	27	"	29	May	2
53	Moreman	"	26	"	29	"	1
83	Newman.....	"	20	"	23	April	26
(70)	Parsons.....	"	25	"	27	"	29
85	Pottawattamie....	"	26	"	29	May	2
33	Purple Yosemite.....	"	27	"	28	April	30
34	Quaker	"	26	"	28	"	30
72	Rachel.....	"	28	"	30	May	2
55	Reed.....	"	26	"	29	"	1
86	Robinson.....	"	20	"	23	April	26
131	Rockford	"	27	"	29	"	30
35	Rollingstone.....	"	23	"	26	"	28
56	Roulette	"	25	"	27	"	29
87	Schley	"	23	"	27	"	29
36	Speer	"	23	"	25	"	27
57	Sucker State.....	"	25	"	27	"	29
37	Van Buren... ..	"	27	"	29	May	1
(83)	Warren	"	16	"	21	April	26
59	Wayland.....	"	26	"	28	"	30
38	Wazata.....	"	17	"	19	"	20
39	Weaver	"	25	"	27	"	28
60	Whitaker.....	"	27	"	28	"	30
61	Wild Goose.....	"	20	"	24	"	27
42	Wolf.....	"	27	"	29	"	30
43	Wyant.....	"	27	"	29	May	1
90	Yellow Transparent...	"	21	"	25	April	28

4. *Insects and diseases.*—Numerous insects and fungi attack the native plums. Much has been written concerning the supposed immunity of the fruit from the attacks of the curculio, and while it may be said that there is no curculio-proof plum, it is also true that the native varieties, as a rule, are less injured than the common or Domestic varieties.*

The fungi which do serious injury to the native plums are indicated for this paper by Dr. E. F. Smith, of the Division of Vegetable Pathology of the national Department of Agriculture, as follows :

“*The curculio prefers the domesticated to the native varieties of plums.”
—C. P. Gillette, *Bull. 9, Ia. Exp. Sta. 388* (1890.) Other observers confirm this opinion. Professor Gillette finds that in central Iowa the plum gouger (*Coccotorus prunicida*) is very injurious, and it attacks the native more than the domestic varieties.

"1. The American varieties suffer little from septoria, or the shot-hole fungus of the leaves. (See Arthur, 5th and 6th reports N. Y. Exp. Sta., with which my observations coincide).

"2. Black-knot occurs on *Prunus Americana* in Michigan thickets, but I have never seen it upon the Chickasaws.

"3. The brown fruit-rot (*Monilia fructigena*) of the stone fruits attacks the native varieties, but they are more exempt, I think, than the varieties of *Prunus domestica*. As in the peach, the fungus attacks the twigs as well as the fruits.

"4. The leaf-rust (*Puccinia pruni-spinosæ*) is said to do injury in the southwestern states, but while I have seen it on peaches in many parts of the country, I have not found it upon the native plums.

"5. Plum-pockets or bladders (*Taphrina pruni*) is a frequent disease upon the native plums. It attacks the Americana and Chickasaw varieties and the Wild Goose. In Michigan I have seen it only on the fruit, which it changes into conspicuous bladders. In Maryland and Georgia it is common on shoots of wild Chickasaws and on cultivated Wild Goose, and it rarely attacks the fruit. It does considerable injury every spring.*

"6. An obscure blight often attacks native plums—as Wild Goose, Robinson, Marianna and others—causing the branches to die back during the growing season. The leaves and large branches and sometimes the whole tree wilt and become brown without apparent cause, and sometimes the tree dies. The roots do not appear to be involved, for they often send up healthy shoots after the entire top has died. This blight has been known in middle Georgia for several years and does more injury to plums than all other troubles combined.†

"7. The peach-rosette also attacks the native plums and perhaps is destined to make more trouble than any other disease in the south and west. (See Jour. Mycology iv. 143; same vi. no. 4; also bulletin of Div. Veg. Pathology on 'Additional Evidence of the Communicability of Peach Yellows and Peach Rosette.')

The fruit-scab (Fig. 11), which injures many varieties, is discussed for me by Professor L. H. Pammel, of the Iowa Agricultural College :

*See Smith, Jour. Mycology, iv. No. 3.

†Ibid.

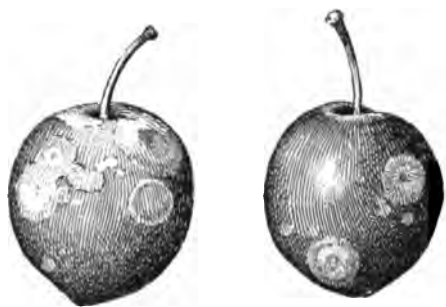


FIG. 11.—Fruit-scab. Natural size,

appearance. These spots are pale greenish or greyish in color and increase in size till in some cases they are half an inch across. They are mostly round with a somewhat paler border. In older specimens the patches are frequently confluent and of darker brown color. In very old specimens, especially in those where the fruit has undergone decomposition, the patches become black and uneven.

“A microscopic examination of the small greyish spots shows a nearly colorless mycelium creeping over the surface. In the darker portions of the large patches are septate hyphæ or threads. In some cases these come through cracks in the cuticle. The hyphæ are irregular in outline and frequently bent. As the material becomes older a dense stroma of short brownish hyphæ appears. This stroma lies between the cuticle and the cellulose layers of the cell-wall. Under favorable conditions it keeps on producing the erect septate hyphæ which bears the slightly colored spores at the end. The spores are oval in shape, pointed at the end, and usually two-celled. On placing the spores in water they germinate in a short time, producing a colorless tube from one of the cells.

“The disease does not impair the quality of the fruit, as the injury extends little beyond the spot, and affects only three or four layers of underlying cells. These cells take on a brown color, and have a slightly bitter taste. The greatest injury arises through the cracks which are frequently found in the older patches, which allow other fungi, like the fruit-rot, to work their way in. So it frequently happens that the rot accompanies the scab. The *cladosporium* or scab fungus causes the fruit to shrivel, in severe attacks.

“*Cladosporium carpo-*
philum: So far, I have
found this fungus only on
the fruit, but in case of the
peach Mr. Galloway re-
cords it upon the leaves
as well. When plums
are ripe or just turning
in color, small round
patches not larger than
a pin-head make their

" Here in central Iowa I have observed this scab upon the following varieties : Speer, Chippeway, Cheney, De Soto, Rollingsstone, Maquoketa (Fig. 11), Pottawattamie and Miner. It appears to be more or less local here as well as elsewhere in the United States. A correspondent has sent me specimens of the fungus on *Prunus Americana* grown in Virginia. The disease has also appeared in Canada, but principally on *P. Americana*, though in one case Professor Craig received specimens on the Blue Orleans (*P. domestica*) from Toronto. It is destructive, as he informs me, on Manitoba yellow plum, Cheney, Rollingsstone, DeSoto and Speer. The disease did not appear, according to Mr. Craig, in Canada on the Central Experimental Grounds last year. Here at Ames it has not appeared on *Prunus domestica*, but in addition to the above, it is found on *P. spinosa*. It has become a very destructive fungus on sour Cherry (*Prunus Cerasus*), damage amounting from 2 to 25 per cent. The disease is undoubtedly on the increase."



FIG. 12.—Fruit-spot.
Natural size.

A fruit-spot (Fig. 12) has been sent me by T. V. Munson, Denison, Texas, on the Golden Beauty. The disease is said to be serious in some years. It does not injure the fruit greatly except to disfigure it and to render it unmarketable. I submitted the specimens to Professor J. E. Humphrey of the Massachusetts Agricultural College, who found the disease to be a phoma, but the exact species could not be determined. It is, no doubt, somewhat allied to the black-rot of the grape, and the treatment used for grapes should be tried upon the plum ; and a similar treatment is advised for the fruit-scab shown in Fig. 11.

There are no data for determining the extent of the native plum industry, but it is safe to say that it is much more important than anyone, except those immediately concerned, has known. There are large areas of the country in which the common or Domestic plums do not succeed, either because of too great cold, too great heat or the serious ravages of the shot-hole fungus. In nearly all of these areas there are native varieties which succeed. The

natives are inferior in size and flavor to the common plums, but it must be remembered that the native plum industry is in its infancy, and that great results should not yet be expected. It is rather a matter of wonder that the present results have been attained with the expenditure of so little effort. The great variation in almost every direction in the existing varieties, and the fact that they spring from three or four distinct species, augur well for the future; while the facts that they find ready sale in the markets* and that many people make their cultivation profitable, are encouragements to present effort.

*"And as for the Wild Goose plum, it is the best we have here. There have been shipped from here as many as 600 boxes of this variety in a single day, and have sold in the Chicago markets at the enormous price of \$2 per one-third bushel box, or \$6 per bushel."—*J. R. Logan, Duquoin, Ill., in Green's Fruit Grower, July, 1891.* Mr. Kerr sold Wild Goose readily in 1889 for 65 to 80 cents for 10-lb. baskets; and in 1891 for 40 to 50 cents.

II. THE CHERRIES.

I. THE SAND OR DWARF CHERRIES.—(Figs. 13 and 14).—The dwarf sand cherry has often attracted attention as a meritorious fruit. In 1867, A. S. Fuller* published an important ac-



count of it and recommended its cultivation for fruit. In 1889, Professor C. E. Bessey called the attention of the American Pomological Society

FIG. 13.—*Sand Cherry (Prunus pumila)*. Natural size. to it as "a promising new fruit from the plains" of Nebraska.† It is only within the last two or three years, however, that the sand cherry has come into actual cultivation for its fruit, although as an ornamental plant it has been sold many years. Professor C. A. Keffer described it last July in a bulletin of the South Dakota Experiment Station‡, and a little later Professor Green of Minnesota did the same.§ Both men have grown it, and have found it to be variable and promising. In South Dakota plants set three years bore heavily the second and third years. The "fruit begins to ripen the first week in August. The cherries on most of the bushes were ripe by August 20th, and some few last into September.

*Small Fruit Culturist, 1st Ed. 183.

†Amer. Pom. Soc. Trans. 1889, 160.

‡Bull. 26, S. Dak. Exp. Sta. 10.

§Bull. 18, Minn. Exp. Sta. 127.

showing a season of from four to six weeks in a seedling plantation. Classifying roughly according to the fruit, we find yellow and black fruited sorts. The yellow fruited sorts, as a class, are earlier than the blacks, and of rather better flavor. They are greenish yellow when fully ripe, and vary in size, the largest being about the size of a medium Early Richmond cherry." The fruits vary greatly in flavor, some being entirely worthless, while others were acceptable for some culinary purposes. "While of little value when the quality of the fruit is considered, it would seem that these dwarf cherries should give rise to a race especially adapted to the northwest. They have withstood all the dry weather of the past three years without injury, and they have been covered with bloom for two seasons, though unprotected during the winter." Professor Green, in Minnesota, has "fruit varying in color from quite light red to almost black, and in form from round-oblate to oval. The largest fruit we have is oval with three fourths inch and five-eighths inch diameters, while one other is round and eleven-sixteenths of an inch in diameter; this is nearly as large as the Early Richmond cherry. The quality varies greatly, some being a mild not disagreeable sub-acid, others insipid, and still others very astringent.

. When cooked it makes a nice sauce. The period of ripening varies from July 24th to August 15th. A peculiarity of the plant is that all the fruit on any plant is ripe at nearly the same time and can all be gathered at one picking.

I consider this cherry not only of prospective value for its fruit, but of immediate value as a hardy shrub." I have been familiar with



the sand cherry for many years, both wild and when transferred to the garden. It is very abundant on the sand dunes of Lake Michigan, where it makes a shrub from five to ten feet high and bears very profusely of vari-

FIG. 14.—*Prunus cuneata*. Natural size.

able fruits. Some of these natural varieties are large, sweet and palatable and at once suggest an effort to ameliorate them. Professor Budd and others suggest its use as a dwarf stock for cherries*, while it is found to grow well, for a time, at least, upon the peach.† Finally, Charles E. Pennock of Bellvue, Colorado, is introducing the Improved Dwarf Rocky Mountain cherry, a description and history of which follow. I am particularly gratified to report this fruit because I remember with great distinctness that a "Rocky Mountain cherry" grew in my father's yard from my earliest boyhood. Pits were brought by a friend from Pike's Peak in an early day. As the western botanies do not mention any dwarf cherry, I have always been puzzled over this friend of my earlier years.‡ Mr. Pennock describes his cherry as follows:§

"I have never seen a bush more than four feet high. They should be planted about eight feet apart, as they grow on the ground. The first I ever saw or heard of was in 1878. I was making and floating railroad ties down the Cache la Poudre river, in the mountains, about eight miles from my present farm. I thought at that time they were the most valuable fruit I ever saw growing wild. I got a start of these cherries, and have been improving them by planting seed (pits) of the best fruit. They vary somewhat in size, flavor, and season of ripening, and are capable of great improvement. I have known only one bush that was not good in my experience with it. We have nearly all kinds of fruit, but we like the cherry to eat out of hand when fully ripe better than any of its season. It ripens a month later than Morello—in fact, I picked them off the bushes and exhibited at our county fair September 23d, 24th, and 28th, where they attracted a great deal of attention. I have learned since I have had these cherries that other residents of the county had them in their gardens more than twenty years ago, and have them yet, so I do not claim to be the discoverer of them, but I believe I am the first to improve them and make their value known to the public. They are very scarce in their wild state here. There are two kinds of them, one

*Bull. 10, Ia. Exp. Sta. 425. Bull. 18. Minn. Exp. Sta. 128. Bailey, Nursery-Book, 159.

†Bailey, Country Gent. li. 676 (Sept. 9, 1886.)

‡Coulter's Manual of Rocky Mt. Botany contains no dwarf cherry.

§Am. Farm and Hort. Apr. 1892, 14.

that grows outside the mountains in the foot-hills, and is in every way inferior to the one that grows near the bank of the Cache la Poudre river. There are not 2,000 of these cherries of mine in existence. I could sell wagon loads of these cherries at 10 cents per quart. I have kept 200 of the young trees, which I intend to send to responsible parties who desire them for testing. The young trees I have are one year from seed. I have had them loaded down at two years of age from seed. They have never failed to bear fruit every year; late frosts never affect them; they are entirely hardy, having endured 40 degrees below zero without injury; ripens when all others are gone; would grace any lawn when in blossom; are easier pitted than other cherries."

Thus far, all appears to be simple enough; but if we begin to enquire into the species of these cherries we find great difficulty, for it is plain that two and perhaps even three species are passing as *Prunus pumila*. Propagators have long recognized two well marked types of sand or dwarf cherry. The commonest species is the one shown, natural size, in Fig. 13. It grows along rivers and sandy or rocky coasts, from northern Maine (and probably from Newfoundland) to Washington, and perhaps even farther south, and ranges westward to the Great Lakes and Manitoba. I do not know if it grows on the sea shore, but aside from a specimen from Aroostook Co., Maine, I have not seen it from New England. It is a *prostrate* or *decumbent* shrub, the roughish dark branches ascending in a straggling manner three or four feet, or sometimes twice that height. The flowers are rather small, with narrow petals. The leaves are *long and pointed* (nearly linear at flowering time), varying from oblanceolate to nearly obovate-lanceolate, or sometimes lanceolate, rather thick and firm and prominently veined, especially beneath, terminating usually in a sharp point and bearing on the upper half short but sharp teeth which, however, are usually smaller than shown in Fig. 13. This species is very variable. The form upon Lake Michigan is characterized by very long and willow-like leaves, and broad-leaved forms occur in other places. Nurserymen take advantage of its straggling habit by grafting it upon standard stocks for the purpose of making a weeping tree. It is sometimes sold as *Cerasus pumila*. A variety *variegata* of this weeping tree is catalogued, but I have not seen it. The sand cherry is the plant which

Linnaeus meant to designate by his *Prunus pumila*.* It is the plant, apparently, which the experiment stations of South Dakota

* Linnaeus founded the species upon a figure by Miller (t. 89, f. 2) and upon a plant cultivated in the Upsala gardens. Miller's figure, so far as it goes, and Linnaeus' characterization, show that Linnaeus meant to describe the prostrate and long-leaved plant which I have above indicated as *P. pumila*. Linnaeus' herbarium affords no aid, according to the following notes upon it, which were recently made by Dr. N. L. Britton, and which he has kindly placed at my disposal. The herbarium contains

- "1. A sheet of the eastern plant [*pumila*], marked by him *pumila*.
- "2. Another sheet also marked *pumila*, but of some other species which I did not recognize.
- "3. Another sheet also so marked, but of some still different thing.
- "4. A fourth sheet from Kalm, which is *P. Americana*, as noted thereon by Dr. Gray."

The synonymy of the two species is briefly as follows :

PRUNUS PUMILA, Linn. Mantissa, 75.

"14. *Pruuus foliis angusto-lanceolatis serrulatis*.

"*Cerasus foliis lanceolatis : glabris integerrimis, subtus caesis, ramis patulis*. Mill. ic. t. 89, f. 2.

"*Cerasus canadensis pumila, oblongo-angustoque folio, fructu parvo*. Hamel. arb. 149, n. 17.

"Habitat in Canada.

"*Frutex statura Amygdali nanae. Pedunculi proprii, uniflora, terni e gemmis lateralibus*. H. U."

P. Susquehanæ, Willdenow, Enum. 519

"*P. pedunculis subsolitariis, foliis obovato-oblongis, subtus glaucis, serratis, basi integerrimis*.

"*Prunus Susquehanæ*. Hortulan.

"Habitat in America boreali.

"*Flores imperfectos tantum vidi*."

In his *Berlinische Baumzucht*, 2d. ed. 306, Willdenow revises his character as follows :

"*Prunus Susquehanæ floribus umbellatis, foliis obovato-oblongis obtuse serratis, basi integerrimis, subtus glaucis*.

"*Prunus Susquehanæ pedunculis subsolitariis, foliis obovato oblongis subtus glaucis, serratis, basi integerrimis* Willd. enum. 519."

The German text which follows affords still stronger proof that Willdenow meant to designate the plant under consideration.

P. depressa, Pursh, Fl. 332.

"*Umbels sessile aggregated, few flowered, calyx obtuse : branches angled depressed-prostrate ; leaves cuneate-lanceolate, rarely serrate, glabrous above, glaucous beneath ; fruit ovate*.

"On the sandy shores of rivers and lakes : Canada to Virginia. v. v.

and Minnesota have described, and it is the one which has been advised as a dwarf stock for cherries.

Another and much rarer cherry is the one shown in Fig. 14, and for which I have used Rafinesque's name *Prunus cuneata*. It grows near lakes and about bogs, mostly in wet or stiff soil, and is often found on hills and low mountains. I have seen it from New Hampshire, Massachusetts, Rhode Island, New York (Ithaca), New Jersey, Pennsylvania, North Carolina, Wisconsin and Minnesota. It is an *erect* or even *strict* shrub with smooth light colored branches, growing from two to four feet high. The flowers are large with broad petals, and usually stand out squarely upon somewhat curved stems. The leaves are *short* and usually *blunt*, obovate, spatulate or when full grown sometimes elliptic-ovate and becoming more or less pointed, thin and inconspicuously veined, the teeth few and the points appressed.

This low shrub which spreads its branches very much, and does not rise above one foot from the ground, is known by the name of *Sand-cherries*. The fruit is black, small and agreeably tasted "

P. incana, Schweinitz in Long's Exped. 2, Append. 113. Bailey, Annals Hort. 1891, 234.

Through the kindness of Mr. J. H. Redfield, of the Philadelphia Academy of Sciences, I have had the privilege of examining Schweinitz's specimens (coll. at Lake of the Woods) and they are unmistakably *P. pumila*

In all these descriptions, the long leaves, prostrate habit and the habitat, apply only to the plant under discussion.

PRUNUS CUNEATA, Rafinesque, Ann. Nat. 11 (1820).

"83. *Prunus cuneata*. Shrubby, branches straight, round, biangular, leaves cuneate, obtuse, crenate, base entire, glaucous beneath; umbels sessile, commonly quadriflore, calix serrulate, rugose transversally.—On the mountains of Pennsylvania, probably a Cherry shrub, it rises two feet, branches dark purple, leaves and flowers small, peduncles short, three to five flowers together, white; it blossoms in May."

The absence of any allusion to long leaves and depressed habit, the obtuse leaves and the mountain habitat, lead me to venture to use this name for the upright dwarf cherry. The leaves of this plant, to be sure, are often acute when mature, but at flowering time they are conspicuously obtuse, and Rafinesque appears to have had them at that stage.

This cherry is in cultivation as an ornamental plant under the name of *Prunus pumila*. I do not know that it has been suggested as a fruit plant.

Professor Porter, of Easton, Pennsylvania, one of the most critical observers of our eastern flora, writes as follows concerning these dwarf cherries: "We have two forms of dwarf cherry very diverse in habit. One [*P. pumila*] grows on the islands and flats of the Delaware, which are composed of gravel and cobblestone drift washed bare by the floods, and are treeless. Here it grows, sending out on all sides strong prostrate branches, often as thick as a man's arm, which form flat patches six feet or more in diameter. The branches are so close together that they hold the fine sand and mud and create low mounds or hillocks, and in the proper season the spaces between them are black with the fruit. The other [*P. cuneata*] occurs in southeastern Pennsylvania on the borders of swamps and remote from river bottoms. It is strictly erect and attains the height of four feet. It is so unlike the type that I have been inclined to regard it as a new species." On the dunes along Lake Michigan *Prunus pumila* grows more erect than those described by Professor Porter, but they always have a prostrate base over which the sand drifts. *P. cuneata* grows at Ithaca in a dryish hill swamp, and it wholly lacks the habit and appearance of the common species.

The third dwarf cherry is the Rocky Mountain plant to which I have already referred, and evidently the same as the one which Professor Bessey has described from the plains of Nebraska. This plant is not mentioned in the Rocky Mountain botanies, although there can be no doubt that it is wild in Colorado and Utah. Dr. C. C. Parry collected it in eastern Colorado in 1867, and apparently the same was found somewhere in the Rocky Mountains, presumably in Colorado, in 1888, by S. M. Tracy. A. S. Fuller also mentions it in the article to which I have already referred. He obtained the seeds from Utah. As compared with *Prunus pumila*, he found this Utah cherry to be "more erect, none of the branches trailing as in the species." Gipson* speaks of the native wild Colorado dwarf cherry as bearing a fruit "especially valuable for pies and preserves, and is often pleasant to eat from the hand.

*Horticulture by Irrigation, 62.

It is wonderfully productive, and will survive all changes and vicissitudes of the most exacting climate." It is interesting to find that this plant was collected so long ago as 1839 by Geyer, in Nicollet's famous expedition, being found on "arid sandy hillsides of the upper Missouri."

The affinity of this western plant is with *Prunus pumila*, but it differs from that species, and I am inclined to regard it as a distinct botanical variety, if not, indeed, a distinct species. It is a low straggling more or less prostrate plant, the tops rising only a foot or two in the plains form, the flowers small, the leaves much like those of *P. pumila* except that they are much shorter (1 to 2 in. long) and spatulate or elliptic when fully grown, the fruit large upon short stems. This plant is so little known that I do not venture to give it a name. Growing in our garden, it has more the aspect and light color of *P. cuneata*, but its thick and pointed leaves appear to distinguish it from that species. It lacks entirely the wand-like and willowy character of *Prunus pumila*; but this species is so variable and so little understood that it would be unsafe to separate the western plant from it upon our present evidence. We are growing this western cherry, as also *Prunus pumila* and *P. cuneata*, from various sources and shall probably soon be able to determine its botanical position.

The sand or dwarf cherries, therefore, are three, all of which are in cultivation: *Prunus pumila*, the true sand cherry grown for fruit and ornament; *Prunus cuneata*, grown for ornament; the sand cherry of the plains and the Rocky Mountains, grown locally in Nebraska and now introduced from Colorado as the Improved Dwarf Rocky Mountain Cherry. Finally, it may be said that the sand plum is a form of the Chickasaw plum as we have already found (See p. 29).

2. "UTAH HYBRID CHERRY."—Under this name there has come into cultivation an anomalous fruit, the history and botanical characters of which I am unable to trace. It is usually referred by the nurserymen to *Prunus pumila*, but the specimens which I have seen do not belong to that species. In fact, as grown by Mr. Kerr, it is a plum, with a stone very like that of the Marianna, and the catalogue cut of the fruit shows a short-stemmed and sutured plum. There are two varieties in cultivation, the black and red. These are described as follows by the

Heikes Nurseries, of Dayton, Ohio, which was one of the first to grow them :

"*Utah Hybrid Cherry, black.*—This is an improved variety of the Dwarf or Mountain Cherry of Utah. The fruit is about one inch in diameter, nearly round ; color dark purple, with a delicate bloom, juicy, pleasant and sweet ; slightly astringent if the skin is pressed too closely. The bush is very dwarfish, but vigorous and prolific. This fruit has the merit of being something entirely distinct from anything cultivated in the way of fruits heretofore. The fruit is exceedingly beautiful; the tree is hardy enough to withstand the severest winters, and begins to bear the first year after planting.

"*Utah Hybrid Cherry, red.*—This is a dwarf variety, evidently belonging to the Chickasaw class, and while it has some merit as a novelty, it is not nearly equal to the above."

Samuel Miller, of Bluffton, Mo., informs me that he obtained the Utah Hybrid Cherry over ten years ago from Nebraska. The Phoenix Nursery Company, of Bloomington, Ill., "have been propagating it for many years" to supply the spontaneous demand for it, but the Company writes me that it "cannot recommend it" and that "the fruit is rather small, of dark purplish red color, and is merely a skin drawn over a pit." The plant sold by the Phoenix Company is a slender under-shrub with elliptic-lanceolate prominently nerved and pointed leaves which are sharply serrate throughout, and which cannot be referred to any form of *Prunus pumila* with which I am acquainted. The tree grown by Mr. Kerr has the half-weeping habit of a Morrello cherry, and the leaves are also very like those of the Morello. The flowers are borne in short-stalked umbels upon wand-like twigs, and they suggest, as do also the leaves, an approach to *Prunus maritima*, the beach plum. The original Utah Hybrid which Mr. Kerr planted, he tells me, had fruit about the size of Bassett's American (See No. 94, Part I), but which ripened earlier than that plum. The present tree, described above, is a seedling of it, but this seedling has larger fruit—as big as a large Napoleon cherry—which is later than the Bassett, and the tree is less dwarf. He considers the Utah Hybrid an inferior fruit.

3. *PRUNUS SHROTINA*, the Wild Black or Rum Cherry. This well known cherry, the wood of which is often used for cab-

inet work and house finishings, is planted for forestry purposes, as an ornamental tree and sparingly for its fruit. Infusions of the bark are used for medicinal purposes and the fruit is often used in the manufacture of cherry brandy or as a flavor to rum. Occasional trees bear fruit of unusual size and attractiveness. As an ornamental plant the Wild Black Cherry possesses decided merits in its attractive habit, clean shining foliage, striking white racemes and handsome fruit. There are several cultivated varieties : *pendula*, a weeping form, worked standard high ; *variegata*, with the leaves more or less discolored with yellow ; *Golden-Leaf*, found wild by Jackson Dawson, of the Arnold Arboretum, and somewhat disseminated, and probably essentially the same as *variegata*; *carthagena*, with small short-elliptic or ovate-elliptic leaves. *Prunus serotina* ranges through the eastern and southern states as far west as Kansas.

4. PRUNUS PENNSYLVANICA, the Bird, Wild Red, Pigeon or Pin Cherry, is occasionally cultivated for ornament, although it is not so well known as its merits deserve. It sprouts badly, a feature which no doubt discourages its dissemination. The species has been lately recommended as a stock for the common orchard cherries.* Professor Budd says that "when top-worked or crown-grafted with vigorous growing sorts it does not appear to have any reserve material to waste in sprouts. We have trees of the Early Richmond and Dyehouse in the state which have not shown a sprout on this stock for twelve years." The union with the orchard cherries, both sweet and sour, appears to be good as a rule, and the species certainly possesses promise as a cheap and hardy stock. The fruit is sometimes used in the preparation of cough mixtures. It is generally distributed throughout the northern half of the Union from the Atlantic to Colorado.

5. PRUNUS VIRGINIANA, the Choke Cherry, is cultivated for ornament. It is scarcely inferior for that purpose to its Old World congener, the true Bird Cherry (*Prunus Padus*), although its flowers are somewhat smaller than in that species, and they are also a few days earlier. If grown as a lawn tree where a symmetrical development can be secured, the Choke Cherry, both in bloom and in fruit, is an attractive object. Although rarely more

*Budd, Bull. 10, Ia. Exp. Sta. 425. Bailey, Nursery Book, 159.

than a large tree-like bush, the Choke Cherry is often confounded with the Wild Black Cherry, but it is readily distinguished by the very sharp small teeth of the leaves. The fruit of the Choke Cherry is commonly red, but amber-fruited plants are occasionally found. This cherry has been mentioned as worthy of attention as a fruit plant, but the fact that none of the racemose cherries (those bearing their flowers in long clusters) have given marked results in this direction, indicates that efforts towards amelioration of the fruit are likely to meet with discouragement. The Choke Cherry is generally distributed east of the Rocky Mountains.

6. *PRUNUS DEMISSA*, the Western Choke cherry, was introduced in 1881 as an ornamental plant by Edward Gillett, Southwick, Mass. Its merits as a cultivated plant are not yet well known. It is much like the Choke Cherry, but more variable in stature and apparently in botanical characters. It occurs from Nebraska to the Pacific coast, extending the length of California and Oregon.

7. *PRUNUS ILICIFOLIA*, the "Islay" of southern California and western Arizona, was introduced to cultivation last year by C. R. Orcutt, of San Diego, California. It is a pleasing ornamental plant with holly-like evergreen leaves (whence the name *ilicifolia*), and a small astringent reddish fruit. In its wild state it reaches a height of 10 or 15 feet. Its merits for cultivation in eastern lawns are yet to be determined.

8. *PRUNUS CAROLINIANA*, the Cherry Laurel, Wild Orange, Mock Orange, or Wild Peach of the southern states, is in cultivation in the south as a small ornamental tree and as a hedge plant. The leaves are long, thick and glossy, and are evergreen. The white flowers are borne in small racemes which are shorter than the leaves. The small black fruit soon becomes dry and is not edible. The species grows wild along rivers from North Carolina to Florida and Texas.

REVIEW.

I. PLUMS.

1. The native plum industry dates from the dissemination of the Wild Goose some 40 years ago. It is only within the last decade, however, that this industry has assumed great importance.

2. Five species and one botanical variety of native plums are now in cultivation for their fruits. 140 named varieties are described in the preceding pages, very many of which are wild varieties transferred to cultivation.

3. Nearly all the commercial varieties belong to three species, —*Prunus Americana*, *P. hortulana* and *P. angustifolia*. These species grow wild in regions east of the Rocky Mountains.

4. *Prunus Americana* grows the farthest north of any of the native plums, and its varieties are the hardiest of any. The species also grows as far south as northern Mexico. The range of adaptability of its varieties may therefore be assumed to be very great. The species is naturally variable, and is therefore attractive to the horticulturist.

5. The fruit of *Prunus Americana* is firm and meaty, usually somewhat compressed or flattened, often marked by a distinct suture, dull in color which ranges through various shades of red and purple to an ill defined and blotched orange. The skin is thick and tough, often acerb, and covered with a pruinose bloom. The stone is large and more or less flattened and winged, and is sometimes nearly or quite free, and the surface is either slightly pitted or perfectly smooth.

6. Forty-five varieties are referred to *Prunus Americana* in the preceding lists. The most popular of these are Cheney, Deep Creek, De Soto, Forest Garden, Itaska, Louisa, Purple Yosemite, Quaker, Rollingstone, Weaver, Wolf. The Americana varieties succeed best, on the whole, in the northern states of the Mississippi valley, as in Wisconsin, Iowa and Minnesota. Some of them, however, are successfully grown in Texas, and on the Atlantic slope so far south as 37° or 38°.

7. *Prunus hortulana* grows wild in the Mississippi valley from northern Illinois to Arkansas, extending eastward into Ken-

tucky and Tennessee and possibly farther, and in the southwest spreading over a large area of Texas. It is naturally variable and has given many important cultivated varieties. It has never been recognized as a distinct species until this year. There are two or three distinct types represented in the species, one of which—the Miner group—appears to possess some radical points of difference from the typical representatives of the species.

8. The fruit of *Prunus hortulana* is firm and juicy, spherical or spherical-oblong, never flattened, and in color ranges through several shades of bright red to clear pure yellow. The skin is thin, often marked with small dots, and is usually covered with a thin bloom. The stone always clings; it is comparatively small, rough, turgid, sometimes prolonged at the ends, but is never prominently wing-margined.

9. The Wild Goose is the best known of the native plums, although its quality is not high. This popularity is due to its productiveness, earliness, beauty, good shipping qualities and to the circumstance that it was early introduced to cultivation. This variety is grown from Iowa, Michigan and New York to Georgia and Texas.

10. The Wild Goose group of plums, as a whole, is well suited to the middle latitudes. The most prominent members of the group are Golden Beauty, Indian Chief, Missouri Apricot, Moreman, Wayland and Wild Goose.

11. The Miner group differs from the Wild Goose or true *Hortulana* group by dull and comparatively thick leaves which are conspicuously veiny below and irregularly coarsely toothed and more or less obovate in outline, and by a rather late and very firm fruit and a flat and nearly or quite smooth stone. The varieties are all much alike. In a wild state, this form of native plum probably grows from Illinois to Tennessee and Arkansas.

12. Ten varieties are referred to the Miner group, of which the most prominent is the Miner. This variety was the first native plum to receive a name from horticulturists. Its history runs back to 1814. Seventy years ago it was known as Old Hickory and General Jackson. Next to the Wild Goose, the Miner is the best known of the native plums. It is hardy in northern Illinois and is popular in the central and some of the southern states.

13. The Chickasaw plums are characterized by slender, spread-

ing and zigzag growth, comparatively small lanceolate or oblong-lanceolate conduplicate (or trough-like) leaves which are shining and closely and finely serrate, and by an early red or yellow soft stringy fleshed fruit which is more or less dotted, and a clinging broad roughish stone. In a wild state, the Chickasaw plum is usually thorny and the thorns persist in a few cultivated varieties. The species grows wild from southern Delaware to Florida and westward to Kansas and Texas.

14. The most important varieties of Chickasaw plums are Caddo Chief, Jennie Lucas, Lone Star, Newman, Pottawattamie, Robinson and Yellow Transparent. The Newman is the most generally known and this is hardy in central New York. The Chickasaws are best adapted to the central and southern states. Many of them are not hardy in Michigan and New York.

15. The Marianna and DeCaradeuc constitute a distinct class or group of plums, and the Hattie is evidently allied to them. They are to be associated with the myrobalan plum. DeCaradeuc is probably myrobalan, and Marianna appears to be a hybrid. The history of the myrobalan is obscure, but it is clearly of Old World origin. It is largely used as a stock, and there are varieties grown for fruit.

16. The Marianna has assumed great importance because of its use as a stock for many plums and allied fruits. Its merits are the ease with which it grows from cuttings, and the facility with which it unites with other species.

17. The beach plum or *Prunus maritima*, of the Atlantic Coast, is in cultivation both for ornament and for fruit. As a fruit plant it is represented only in Bassett's American, a fruit of little value.

18. The Pacific wild plum, *Prunus subcordata*, was introduced to cultivation in 1889 as a possible fruit plant, but its merits are not yet determined.

19. Hybrids appear to occur between the Wild Goose and the peach. J. W. Kerr, of Maryland, has produced such a hybrid, and the so-called Blackman plum appears to be another.

20. Some varieties of native plums, notably Wild Goose and Miner, are not fertile with themselves, and this fact has undoubtedly retarded the progress of native plum culture. This infertility is due to comparative impotency of pollen upon flowers of

the same variety rather than to any structural imperfection in the flowers themselves.

21. This infertility is avoided by mixed planting, by means of which foreign pollen is supplied to the impotent varieties. Care should be taken to associate varieties which bloom at the same time, and with this precaution the ordinary mixed or alternate planting, at usual distances, appears to be successful.

22. The best stocks for native plums are probably seedlings of the same species, although they grow well, as a rule, upon related species and even upon the peach in some instances. Perhaps the most popular stock at present is the Marianna, because of its habit of growing readily from cuttings, and so far it appears to have given satisfaction. The Chickasaw and Hortulana types succeed well upon the peach. Chickasaw stocks sprout so badly that they are in disfavor. In the north, Americana stocks are popular for all the varieties which succeed there.

23. As to the best varieties, there is great difference of opinion. In the northernmost states the Americana class is most reliable, although some of the Hortulanas succeed. For the south the Chickasaws are numerous and popular. The Hortulanas occupy an intermediate position. The merits of particular varieties must be gleaned from the tables on page 48 and succeeding pages.

24. The native plums are in most regions comparatively free from insect abuses. Although there are no curculio-proof plums, the curculio does less damage to the native varieties than to the common or Domestica types.

25. Among diseases, a mysterious blight and the peach-rossette are prominent in the south. A fruit-scab and fruit-spot also occur. The septoria or shot-hole fungus—which causes the serious shedding of leaves in the Domestica plums—does little damage upon the natives. The black-knot, brown fruit-rot and plum-pockets are other diseases which the grower will be likely to meet.

26. As a whole, the native plum industry has made astonishing progress and it has already assumed large proportions. It is certain to occupy a large place in future American horticulture.

II. CHERRIES.

27. Eight and perhaps ten species of native cherries are in cultivation. Of these, three are grown for fruit, and all but one or two are cultivated for ornament. None of the species have gained much prominence under cultivation, however. Most of them are of comparatively recent introduction.

28. The so-called dwarf or sand cherries are much confused, and two, perhaps three species, are passing as *Prunus pumila* : (a) The true *P. pumila*, or sand cherry, is a low straggling shrub, growing along rivers and coasts from Maine to Pennsylvania and Manitoba. It has long thick leaves, and produces cherries of variable size, color and quality. Some of these varieties give great promise as garden fruits, and they are already under test at experiment stations. The plant is also being tested as a stock for dwarf cherries. (b) *P. cuneata* is a slender upright shrub with larger flowers and shorter obtuse spatulate or obovate thin leaves growing in cooler lands from New England to North Carolina and Minnesota. It is in cultivation as an ornamental plant under the name of *Prunus pumila*. (c) The representative of *P. pumila* upon the plains of Nebraska and in the Rocky mountains is a very low plant with short thick leaves and large short-stemmed fruit, the botanical position of which is yet unknown. It is now in cultivation as the Improved Dwarf Rocky Mountain Cherry.

29. The Utah Hybrid Cherry is a fruit of uncertain value and doubtful affinity. Two varieties, the black and red, are in cultivation. It probably comes from some part of the western plains or the Rocky mountain region, but its wild prototype is not known.

30. Other native cherries in cultivation are: *Prunus serotina*, the Wild Black Cherry; *P. Pennsylvanica*, the Bird, Pin or Wild Red Cherry; *P. Virginiana*, the Choke Cherry; *P. demissa*, the Western Choke Cherry; *P. ilicifolia*, the Islay of the Pacific slope; *P. Caroliniana*, Cherry-Laurel or Mock Orange of the southern States.

L. H. BAILEY.

Bulletin 39.

July, 1892.

Cornell University Agricultural Experiment Station.

AGRICULTURAL DIVISION.

Creaming and Aerating Milk.



By HENRY H. WING.

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BULLETINS OF 1892.

- 38. The Cultivated Native Plums and Cherries.
- 39. Creaming and Aerating Milk.

CREAM RAISING BY DILUTION.

It is well known that where cream is separated from milk by the deep setting gravity process, the best results are obtained where the temperature of the milk is quickly brought down to and maintained at about forty degrees for twelve hours. The winter of 1889-90 was so warm and open that many dairymen failed to secure a supply of ice and in the ensuing summer began to suffer loss because they were not able to sufficiently lower the temperature of the water surrounding the cans in their creamers. To obviate this difficulty it was recommended that water should be added to the milk to facilitate the creaming. Two different systems were mainly recommended: one, that twenty-five to thirty-three per cent. of hot water (135 deg. F.) be added to the milk in order to raise the temperature of the whole mass to at least one hundred degrees, so that in cooling down as low as possible,—usually to about sixty degrees F—there would be approximately the same range of fall as there would be in cooling down to forty degrees with ice. The other recommendation was that an equal bulk of cold water (60 deg.) be added to the fresh milk before setting. This was based on the idea that the increased fluidity thus given to the milk would render the creaming process as complete as though the milk were cooled down to forty degrees with ice.

Since that time, experiments to test the value of these recommendations have been conducted at several of the experiment stations and the results are found in the following publications:

University of Illinois Experiment Station Bulletin No. 12, page 376, and Bulletin No. 18, page 30. Cornell University Agricultural Experiment Station Bulletin Nos. 20 and 29. Vermont Agricultural Experiment Station, Newspaper Bulletin No. 3, and Fourth Annual Report, pages 100-107.

The results of these various experiments have not been entirely concordant; although in the main they have not been favorable to the practice of dilution. It was to settle some of these points that the experiments reported in the following pages were conducted.

The whole question of dilution has resolved itself into several phases, the more important of which are the following:

1st. Dilution with one-fourth to one-third of hot water, 135°F, and setting in deep cans at a temperature as low as can be obtained without the use of ice, not below fifty-five degrees.

2d. Dilution with one-half to equal quantities of cold water and setting under the same conditions as above.

Both of these being intended as substitutes for the use of ice in cold deep setting in the summer time.

3d. Dilution with one-fourth to one-third of hot water (135 deg.) setting in deep cans in ice water. (40 F.)

This last intended to overcome the difficulty of complete creaming often found in the fall and early winter with the milk of cows far advanced in the period of lactation.

Of the experiments referred to above those conducted by the Illinois Station were laboratory experiments, in which only small quantities of milk—one quart or less—were used and are therefore not considered in the following discussions. The experiments at this Station and those conducted by the Vermont Station were all made with ordinary sized deep setting cans under the conditions that prevail on the farm.

In none of the experiments, either at the Vermont Station or at this Station, has there been any benefit from the dilution where cold water was used as the diluent and where the cans were set either in cold water (40 deg.), in warm water (60 deg.) or in air, and at neither Station has there been any advantage from the dilution where hot water was used as the diluent and the cans subsequently set in cold water (40 deg.)

In regard to dilution with hot water and the subsequent setting of the cans in warm water (60 deg.) the Vermont Station found (Fourth Annual Report, page 102) in eighteen tests with four different sets of cows, the following average percentages of fat in the skimmilk:

Diluted set at 60 (6 trials),	.52	per cent. of fat in skimmilk
Undiluted set at 60 (5 trials),	.82	" " " "
" " " 40 (7 trials),	.44	" " " "

On the other hand we have found (Bulletin No. 20, pages 62-65) in twenty-three trials with mixed herd milk the following average percentages of fat in the skimmilk :

Diluted set at 60 (10 trials)	1.11	per cent. of fat in the skimmilk.
Undiluted set at 60 (2 trials)	.89	" " " "
" " " 40 (11 trials)	.23	" " " "

It will thus be seen that the results at the Vermont Station from diluting and then setting at sixty were much better than where the milk was not diluted and set at the same temperature, and nearly as good as where the undiluted milk was set at forty, while at this Station the results from diluting and setting at sixty were not as good as from the undiluted milk set at the same temperature and much poorer than from the undiluted milk set at forty. This, then, was the chief point of difference in the results obtained at the two Stations and it was to this point particularly that the experiments following were directed.

In all cases the milk was set for twenty-four hours before skimming. The analysis of the fat in the skimmilk was made by Mr. G.W. Cavanaugh, assistant chemist of the Station, by the Babcock Asbestos Gravimetric method. The details of setting, skimming and sampling, and the determining of the fat in the whole milk by the Babcock Method were all done by the writer. Cooley cans were used in all cases, and in skimming great care was taken that there should uniformly be left one whole space of skimmilk under the cream line : that is to say, the cream was drawn down to the last mark but one of the scale. By far the larger number of the tests were made with the mixed evening milk of the University herd consisting of grade Holstein and grade Jersey cows which had been in milk from three to six months. A few tests were made with milk from the Jersey cows that were freshest and from the Holstein cows that were longest in milk ; these will be noticed in detail further on. In all cases a full can twenty inches deep, was used for each test, and in all cases a diluted and undiluted can were set from the same milking. In every instance where milk was diluted the percentage of fat in the skimmilk is corrected for the amount of water added. Table I

TABLE I—MIXED HERD MILK SET AT 60.

Date.	Milk. Lbs.	Water. Lbs.	Tempera- tures F.				Skim milk. Lbs.	Cream. Lbs.	Per cent. fat in whole milk.	Diluted.		Not diluted.	
			Milk.	Water.	Set.	Creamer.				Per cent. fat in skim milk.	Fat lost in 100 lbs. milk set. Lbs.	Per cent. fat in skim milk.	Fat lost in 100 lbs. milk set. Lbs.
Feb. 19.....	54 18	84	135	97 65	60		12	4 2	1.07	.89			
" 19.....	72	84		84 65	59		13	4.2				1.88	1.09
" 22.....	54 18	90	136	99 64	59.5		12.5	4.2	.52	.43			
" 22.....	2	90		90 64	57.5		14.5	4.2				.97	.77
" 23.....	54 18	89	135	101 66	60.75		11.25	4.3	.80	.68			
" 23.....	72	89		89 66	58.50		13.5	4.3				1.12	.91
" 28.....	54 18	88	134	98 57	58		14		.85	.28			
" 28.....	72	88		88 57	57		15					.65	.51
" 29.....	54 18	86	134	97 60	59.75		12 25	4.4	.68	.56			
" 29.....	72	86		86 60	58		14	4.4				1.18	.95
Mar. 1.....	54 18	86	135	96 60	61		11	4.1	.68	.58			
" 1.....	72	86		86 60	58.5		13.5	4.1				.96	.78
" 13.....	54 18	86	135	96 60	60 75		11.25	4.3	.85	.72			
" 13.....	72	86		86 60	57 75		14.25	4.3				.82	.66
" 14.....	27 9	84	136	96 58	29.5		6.5	3.9	.88	.72			
" 14.....	36	84		84 58	30		6	3.9				1.14	.95
" 15.....	27 9	86	132	95 58	30		6	3.9	.78	.61			
" 15.....	36	86		86 58	29.5		6.5	3.9				1.25	1.02
" 26.....	27 9	88	136	101 56	29.5		6.5	4.1					
" 26.....	36	88		88 56	28.5		7 5	4.1				.67	.53
" 27.....	54 18	90	135	100 64	60.25		11.75	4.5	.81	.68			
" 27.....	36	90		90 64	30		6	4.5				.70	.58
" 28.....	27 9	88	136	102 61	31		5	4					
" 28.....	36	88		88 61	30		6	4				1.21	1.01
" 31.....	27 9	87	135	102 62	30		6	4.1	.98	.78			
" 31.....	36	87		87 62	29 75		6.25	4.1				1.17	.97
Apr. 2.....	27 9	91	135	103 65	30		6	4.7	1.08	.90			
" 2.....	36	91		91 65	29		7	4.7				1.68	1.35
" 4.....	27 9	92	135	102 62	29		7	4.2	.81	.25			
" 4.....	36	92		92 62	29		7	4.2				.92	.74
Average.....										.76	.62	1.05	.85

gives the details of the trials where the temperature of the creamer was kept as near as might be at sixty degrees and where the mixed herd milk was used. In this and the following tables the figures included between the spaces refer to diluted and undiluted portions of the same samples of milk.

It will be seen that in the above fifteen tests covering a period of about six weeks that there was a considerable benefit in the creaming resulting from the dilution. The average percentage of fat in the diluted samples being .76 per cent and in the undiluted samples 1.05 per cent or .29 per cent in favor of the dilution.

Moreover, this advantage is nearly constant, there being only two cases (March 13th and 27th) in which the undiluted samples showed less fat in the skimmilk than the diluted.

Six trials were also made with the milk of the four Jersey cows of the herd that were freshest in milk. These trials were made between the 14th and 31st of March and are shown in detail in Table II below. The dates of calving of the various cows were as follows: No. 1, Jan. 15; No. 2, Jan. 16; No. 3, Feb. 8; No. 4, March 5.

TABLE II.—JERSEY MILK SET AT 60.

Date.	Milk. Lbs.	Water. Lbs.	Temperatures F.			Skim Milk. Lbs.	Cream. Lbs.	Per cent fat in whole milk.	Diluted.		Not diluted.	
			Milk.	Water.	Set.				Per cent fat in skim milk.	Fat lost in 100 lbs. milk set. Lbs.	Per cent fat in skim milk.	Fat lost in 100 lbs. milk set. Lbs.
Mch. 14.....	27	9 72	135	90 58	30	6	5 2	.72	.60			
" 14.....	18	72		72 58	14.5	3.5	5.2			1.50	1.21	
" 15.....	27	9 84	134	95 58	29.5	6.5	5.6	.56	.46			
" 15.....	18	84		84 58	14	4	5.6			1.46	1.13	
" 21.....	27	9 84	135	100 64	31 5	4.5	5.4	.60	.53			
" 21.....	17	84		84 64	14.5	2.5	5.4			.82	.70	
" 26.....	27	9 88	136	101 56	28.5	7.5	5.5	.12	.10			
" 26.....	18	88		88 56	13.5	4.5	5.5			.57	.43	
" 28.....	27	9 88	135	101 61	30	6	5.1	.80	.67			
" 28.....	18	88		88 61	15	3	5.1			1.02	.85	
" 31.....	27	9 85	137	100 62	30	6	5.6	.77	.65			
" 31.....	17	85		85 62	13.5	3.5	5.6			1.41	1.12	
Average									.60	.50	1.13	.91

It will be seen that with this milk, as with the mixed herd milk, that there was considerable advantage resulting from the dilution. In fact, the difference was somewhat greater than with the mixed herd milk.

Further, two trials were made on April 2d and 4th with the milk of the five Holstein cows that had been longest in milk. The results of these trials are given in Table III. The dates of calving of the cows are as follows: No. 1, Dec. 27, 1890; No. 2, Sept. 21, 1891; No. 3, Sept. 29; No. 4, Oct. 2; No. 5, Oct. 28.

TABLE III.—HOLSTEIN MILK SET AT 60.

Date.	Milk. Lbs.	Water. Lbs.	Tempera- tures F.				Skim milk. Lbs.	Cream. Lbs.	Per cent. fat in whole milk.	Diluted.		Not diluted.	
			Milk.	Water.	Set.	Creamer.				Per cent. fat in skim milk.	Fat lost in 100 lbs. milk set. Lbs.	Per cent. fat in skim milk.	Fat lost in 100 lbs. milk set. Lbs.
Apr. 2.....	27	9	87	135	100	65	31	5	3.5	.77	.67		
" 2.....	18		87		87	65	14	4	3.5			.95	.74
" 4.....	27	9	92	135	102	62	30.75	5.25	3.4	.48	.41		
" 4.....	18		92		92	62	15	3	3.4			.68	.57
Average.....										.63	.54	.82	.66

The Holstein milk also showed an advantage resulting from the dilution, but not so great as either the Jersey or the mixed herd milk.

While in all of the milk set at sixty degrees there was a distinct advantage arising from the dilution, still this diluted milk set at sixty was not so perfectly skimmed as the undiluted milk when set at forty degrees. Eight trials were made where both diluted and undiluted milk were set at forty degrees, or, in other words, in ice water, and are shown in detail in Table IV. The tests covered the same period as those made at sixty, and were made with milk of the same character. The first five were made from mixed herd milk; the next two from milk from the same Jersey cows as those detailed in Table II, and the last one from the same Holstein cows as those detailed in Table III.

TABLE IV.—JERSEY, HOLSTEIN AND MIXED MILK SET AT 40.

Date.	Milk. Lbs.	Water. Lbs.	Tempera- tures F.				Skim milk. Lbs.	Cream. Lbs.	Per cent. fat in whole milk.	Diluted.		Not diluted.	
			Milk.	Water.	Set.	Creamer.				Per cent. fat in skim milk.	Fat lost in 100 lbs. milk set. Lbs.	Per cent. fat in skim milk	Fat lost in 100 lbs. milk set. Lbs.
Feb. 20.....	54	18	87	140	100	44	58	14	4.4	.82	.26		
" 20.....	72	87			87	44	54.25	17.75	4.4			.25	.19
" 21.....	54	18	88	136	99	44	57.5	14.5	4.4	.20	.16		
" 21.....	72	88			88	44	53.75	18.25	4.4			.24	.18
" 24.....	54	18	87	134	97	45	56.25	15.75	4.2	.28	.18		
" 24.....	72	87			87	45	53.5	18.5	4.2			.17	.13
" 25.....	54	18	90	134	100	46	57	15	4.4	.28	.18		
" 25.....	72	90			90	46	54.25	17.75	4.4			.26	.20
Mch. 30.....	27	9	86	135	100	44	29	7		.82	.26		
" 30.	36	86			86	44	27	9				.85	.26
" 17.....	27	9	88	136	97	44	29	7	4.7	.11	.09		
" 17.....	18	88			88	44	13.5	4.5	4.7			.18	.14
" 30.....	27	9	86	135	100	44	28	8	5.	.08	.06		
" 30.....	18	86			86	44	13	5	5.			.12	.09
April 5.....	27	9	90	138	103	46	29.75	6.25	3.3	.81	.25		
" 5.....	18	90			90	46	14.5	3.5	3.3			.28	.23
Average.....										.23	.18	.23	.18

It will be seen from a study of this table that the creaming, both of the diluted and undiluted milk, was much more perfect than where the milk was set at sixty; and moreover it will be seen that, as between the diluted and undiluted milk, there was no difference whatever in the efficiency of the creaming when both were set at forty degrees.

A further disadvantage of diluting with warm water arises from the decreased value of the skim milk for feeding purposes because of its dilution. Milk diluted with warm water and set at sixty also has a tendency to quickly become sour. In many of the trials the milk and cream was sour and thick at the end of twen-

ty-four hours. The increased tank room, necessary where dilution is practiced, is also a disadvantage of the system.

During the same period that these other tests were going on, occasionally a can of diluted milk was set in the open air in the dairy room. The results of these tests are shown in Table V, and it will be seen that while the temperature of the room was, in most cases, nearly as low as the temperature of the creamer, the percentage of fat in the skim milk was in general considerably larger than where the milk was set in water.

TABLE V.—MIXED HERD MILK SET IN AIR.

Date.	Milk. Lbs.	Water. Lbs.	Temp. room.	Skim milk. Lbs.	Cream. Lbs.	Per cent. fat in skim milk.	Fat lost in 100 lbs. milk set. Lbs.
Feb. 22.....	27	9	62-74	27	9	2.69	2.02
" 23.....	27	9	38-48	29 75	6.25	.44	.36
" 24.....	27	9	48	27.75	8.25	.84	.65
" 25.....	27	9	48	31	5	.99	.85
" 28.....	27	9	38-40	29.5	6.5	.51	.42
" 29.....	27	9	38-40	30.5	5.5	.78	.62
Mar. 1.....	27	9	34-40	30	6	.81	.26
" 13.....	27	9	42	29.5	6.5	.87	.31
" 14.....	27	9	44	30	6	.60	.50
Average.....						.88	67
Average excluding first trial.....						.60	.50

SUMMARY.

Bringing together the results of all the trials detailed in this bulletin, we have the following averages :

	Diluted.	Not diluted.
Set at 60 :		
Mixed herd milk, fifteen trials.....	.76	1.05
Jersey milk, six trials.....	.60	1.13
Holstein milk, two trials.....	.63	.82
Average of all, twenty-three trials.....	.69	1.05
Set at 40 :		
Mixed herd, Jersey and Holstein milk, eight trials.....	.23	.23
Set at 38-48 in Air :		
Mixed herd milk, eight trials..	.60	

Combining these results with the former results at this Station and the results at the Vermont Station, we have the following average percentages of fat in the skim milk under the different systems :

Diluted set at 60 (39 trials)	.77 per cent.
Undiluted set at 60 (30 ")	1.00 "
" " 40 (26 ")	.29 "

It would seem, therefore, that while when the milk is set at sixty degrees, or thereabouts, there is considerable advantage, so far as the efficiency of creaming is concerned, in diluting it with twenty-five per cent. of warm water ; this dilution cannot be regarded as a substitute for setting without dilution in ice water, and it has the further disadvantage of requiring increased tank capacity and producing a rapidly souring cream.

BERRIGAN SEPARATOR.

At the solicitation of the Berrigan Separator Co., Avon, N. Y., who furnished a machine for the purpose, we have made a somewhat careful test of the merits of this system of separating cream from milk.

The Berrigan separator, so called, is not a separator in the accepted sense of the term ; that is, it does not separate the cream from the milk continuously as the milk passes through the machine. The milk simply undergoes a treatment in the machine, by virtue of which it is supposed that the cream afterward more readily separates from the milk by gravity process.

The apparatus and treatment is comparatively simple. The machine itself consists simply of a cylindrical chamber, capable of being closed air tight. An air pump is attached to one side connected with the chamber by means of suitable valves and fittings, so that the air within the chamber can be compressed to any desired degree. The method of operation is simply to fill the chamber nearly full of milk, to which twenty per cent. of water has been added, close the opening and apply as quickly as possible, an air pressure of thirty pounds per square inch. The milk is allowed to remain under this pressure for two minutes when it is drawn off and set in any ordinary vessel. It is claimed by the

manufacturers that the temperature of the milk at the time of applying the pressure, the temperature of the water added and the temperature of the air in which the milk is afterwards set, are all immaterial, and that by means of this process the cream will all rise inside of twelve hours as completely as with any of the ordinary gravity systems of setting, as may be seen from the following extracts from their circular :

"The best and quickest results will be secured when the milk to be treated is rich in cream, from a new milch cow, and treated while the milk is warm, immediately after the milking. In such a case the cream will probably be up in one hour.

"The poorest result will be found when the cow has been long in milk, when the milk is poor in cream and has stood for some time and become chilled. In such cases two hours may be required to raise the cream.

"If the milk is allowed to stand in the raising vat about seven hours, the fat will rise to within 2-5 of 1 per cent, and if allowed to stand 24 hours, the fat will practically all rise. Much closer results will be obtained right along in practice than by any other known system."

The machine arrived at the Station on March 15th and a member of the company set it up and gave instructions in regard to its workings. From that time until the 1st of April thirteen tests were made with it, on as many different days. Care was taken to follow the directions of the company closely, particularly in regard to applying the pressure quickly (from six to eight seconds were usually required to raise the pressure to thirty pounds per square inch) to apply the proper amount of pressure (thirty pounds) and to allow the pressure to remain on the specified time (two minutes). The milk was diluted with one-fourth its weight of cold water and was set in the can provided by the company, in the open dairy room, except in a few instances when Cooley cans were used. At the time each test was made, another sample of the same portion of milk that received no treatment whatever was set by the side of the treated portion of milk in a Cooley can. The can accompanying the Berrigan separator was only a little more than half as deep as an ordinary Cooley can which is twenty inches. In all cases the mixed milk of the University herd was

used and the details of the experiments are shown in the table below.

TABLE VI BERRIGAN SEPARATOR.

Date.	Milk. Lbs.	Water. Lbs.	Temp. set. °F.	Temp. room. °F.	Skim milk. Lbs.	Cream. Lbs.	Per cent fat in whole milk.	Berrigan treatment.	Untreated.		
							Per cent fat in skim milk.	Fat lost for 100 lbs. milk set. Lbs.	Per cent fat in skim milk.	Fat lost for 100 lbs. milk set. Lbs.	
March 15....	30	10	60	54	26.5	13.5	3.4	.43	.28		
" 16...	28	7	60	53	27.	8.	4.2	.85	.27		
" 16....	36		84		29.5	6.5			.96	.79	
" 17...	36	9	69	54	31.5	13.5	3.6	.66	.46		
" 17....	36		88		29.5	6.5			1.12	.92	
" 17...	28	7	69	54	29.	6.	3.6	.73	.60		
" 17....	36		88		29.5	6.5			1.12	.92	
" 19...	32	8	81	62	30.	10.		.73	.54		
" 20...	32	8	74	63	28.	12	3.7	.60	.42		
" 20....	36		84		29.5	6.5			.88	.72	
" 20...	28	7	74	63	29.5	5.5	3.7	.85	.72		
" 20....	36		84		29.5	6.5			.88	.72	
" 21...	28	7	70	54	30.	5.	3.8	.69	.59		
" 21....	35.5		83		29.	6.5			1.08	.88	
" 26...	28	7	76	60	22.25	12.75	4.1	.68	.43		
" 26....	36		88		30.5	5.5			1.22	1.04	
" 27...	32	8	70	54	26.25	13.75	4.5	.68	.41		
" 27....	36		90		29.75	6.25			.97	.80	
" 28...	32	8	72	55	25.5	14.5	4.	.46	.29		
" 28....	36		88		29.	7.			1.84	1.08	
" 29...	32	8	74	56	25.5	14.5	4.4	.38	.24		
" 29....	36		88		29.5	6.5			1.16	.95	
" 30...	32	8	77	56	25.5	14.5		.50	.32		
" 30....	36		86		29.	7.			.95	.77	
Average								.59	.43	1.06	.87

It will be seen that while better results were obtained by the Berrigan treatment than in the untreated milk set alongside, yet

the results obtained (.59 of one per cent. of fat in the skim milk) would not be called satisfactory creaming. That is, we should expect, by the use of a deep setting gravity system in ice or with any of the forms of centrifugals, to get a skim milk much poorer in butter-fat than was this.

To see if the Berrigan treatment would have any effect when the milk was afterwards set in deep cans in ice water, two trials were made. In each case, a Cooley can full of milk that had been through the Berrigan treatment, and another from the same sample of milk not treated, were set in the Cooley creamer with the water at a temperature of forty to forty-five. The results are shown below.

TABLE VII.

Date.	Milk. Lbs.	Water. Lbs.	Temp. set. ° F.	Temp. water in tank. ° F.	Skim milk. Lbs.	Cream. Lbs.	Per cent. fat in whole milk.	Berrigan treatment.		Untreated.	
								Per cent. fat in skim milk.	Fat lost for 100 lbs. milk set. Lbs.	Per cent. fat in skim milk.	Fat lost for 100 lbs. milk set. Lbs.
March 19.....	28	7	81	43	27.	8.		.43	.43		
" 19.....	37.5		84		28.	9.5				.37	.28
April 5.....	36		87	46	27.5	8.5	4.4	.18	.18		
" 5.....	36		90		27.	9				.28	.21
Average.....								.31	.31	.33	.25

It will be seen that in the two tests made, practically the same results were obtained from the untreated milk and the milk that had gone through the Berrigan machine. In one case the treated milk was diluted, and in the other not diluted.

CENTRIFUGAL SEPARATION.

During the time in which the preceding tests were made, occasional milkings were creamed with a Centrifugal machine. This was done in part to test the work done by the machine and in part to check the results that were being obtained in the other methods. The larger number of the tests were made with a Hori-

zontal De Laval Separator. Toward the end of the series of tests several separations were made with the Baby No. 2 machine, sent on for the purpose by the De Laval Separator Co. The details of the work of these machines are shown in Tables VIII. and IX. below.

TABLE VIII.—HORIZONTAL CENTRIFUGAL.

Date.	Milk. Lbs.	Skim milk. Lbs.	Cream. Lbs.	Per cent. of fat in whole milk.	Per cent. of fat in skim milk.	Fat lost in each 100 lbs. of whole milk. Lbs.	Separated per hour. Lbs.
Feb. 26.....	209.5	172.5	37.	3.9	.20	.16	320
Mch. 12.....	270.	219.5	50.5		.22	.18	350
" 18.....	227.25	187.25	40.	4.5	.16	.13	370
" 31.....	166.5	143.5	23.	3.8	.11	.09	370
Apr. 1.....	134.	116.	18.	3.6	.21	.18	380
" 1.....			42.	3.9	.20		395
" 2.....	95.5	78.5	17.	4.1	.21	.17	360
" 3.....	99.	83.5	15.5	3.6	.21	.18	370
" 4.....	85.	72.5	12.5	4.2	.17	.15	340
Average.....					.19		360

TABLE IX.—BABY CENTRIFUGAL, NO. 2.

Date.	Milk. Lbs.	Skim milk. Lbs.	Cream. Lbs.	Per cent. of fat in whole milk.	Per cent. of fat in skim milk.	Fat lost in each 100 lbs. of whole milk. Lbs.	Separated per hour. Lbs.
Apr. 6.....	62.5	52.75	9.75	4.3	.12	.10	265
" 19.....	189.5	162.25	27.25		.08	.07	270
May 3.....			30.5		.11		320
" 5.....	201.	165.	36.		.05	.04	280
" 12.....	201.5	169.5	32.		.08	.07	275
Average.....					.09		280

It will be seen that the Centrifugal separator, and more particularly the Baby No. 2, offers the most effectual means of removing the cream from the milk, only nine hundredths of one per cent. of fat remaining in the skim milk from the Baby separator. This hardly needs comment as it has been shown before in numerous instances, under widely varying conditions, that so

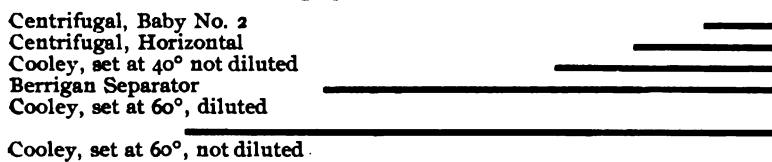
far as efficiency of creaming is concerned, we have no means so effectual as the Centrifugal separator.

SUMMARY.

Below is brought together the average percentage of fat in the skim milk under the various systems. These averages are made from a sufficiently large number of tests to fairly indicate the results that will be likely to be obtained under the best conditions.

	Per cent. of fat in skim milk.
Centrifugal, Baby No. 2.....	.09
Centrifugal, Horizontal	.19
Cooley, set at 40 not diluted.....	.29
Berrigan separator.....	.59
Cooley, set at 60 diluted.....	.77
Cooley, set at 60 not diluted	1.00
Average percentage of fat in whole milk.....	4.24

The above summary is shown graphically below and serves to teach the eye more readily the relative losses of fat under the different systems. In the horizontal lines, each inch represents one quarter of one per cent. of fat. If the fat in the whole milk had been platted in the same way it would have reached four and one quarter times across the page.



AERATION AND AERATORS.

The matter of the aeration and proper cooling of milk is one of prime importance to dairymen, and particularly to milk shippers. Attention has been called to this factor in the keeping of milk only comparatively recently and during the past year there have been sent to us several forms of aerators and coolers with the request that a test be made of their comparative merits and advantages. Accordingly tests of the following aerators have been made: They were respectively the "Star Milk & Cream Cooler," manufactured by Evans & Heulings, Haddonfield, N. J. Two corrugated sheets of tin are placed near together and so arranged

that a stream of water flows constantly between them on the inside; at the same time the milk to be cooled drips slowly over the outside of the corrugated tins. This machine requires a connection with running water, or if running water is not at hand, water must be supplied by means of a tank suitably elevated to give sufficient pressure. Second, the "Champion Milk Cooler," manufactured by the Champion Milk Cooler Co., Cortland, N. Y. This cooler consists of a conical tin vessel arranged to hold ice-water. Upon this vessel is fixed a receiving tank, from which the milk drops in a fine stream and passes down the sides of the main tank and is collected at the bottom. Third, the "Powell" aerator manufactured by J. D. Powell, Golden's Bridge, N. Y. This instrument is intended to aerate without cooling and acts upon the principle of forcing air through milk contained in an ordinary can. It is very simple, consisting merely of a hollow tin plunger with small perforations on the upper side, this instrument being plunged into the milk carries with it air which escaping from the perforations, bubbles up through the milk and so aerates it.

The following tests show the capacity of the "Star" aerator. It was connected with the University water works through a half-inch pipe and the water was allowed to flow through constantly at full head.

TABLE X.—STAR AERATOR.

Date.	Milk. Lbs.	Water used. Lbs.	Temp. water. F.	Temp. milk before aerating. F.	Temp. milk after aerating. F.	Pounds aerated per hour.
March 2.....	79.25	118	36	84	48	475
" 3.....	84	102	36	86	48	
" 7.....	82.50	97	36	89	51	620
" 5.....	74	176.5	36	88	43	315
" 6.....	80	190.5	36	89	44	
" 16.....	78 25	246.5	38	84	43	260
" 29.....	65.5	163.5	36	88	43	302
April 3.....	78	201	36	92	42	310
Aver. 1-3.....	82	106	36	86	49	545
" 4-8.....	75	196	36	88	43	297

In the first three trials the milk was allowed to run from the receiving tank at full head. With the water at 36 degrees F. and using about thirty per cent. more water than milk the cooler reduced the milk to fifty degrees F. at the rate of 550 lbs. per hour. In the last five trials the cock of the receiving tank was partially shut off so that the milk ran slower, the water running the same as before. Under these conditions with water of the same temperature and using nearly three times as much water as milk, we were able to cool the milk to 43 degrees at the rate of 300 lbs. per hour. We think this machine is capable of bringing the milk very near to the temperature of the water at the rate of from 250 to 300 lbs. per hour.

The tests of the Champion Aerator were made by filling the cooling tank with water and ice. This was done in all cases some little time before the aerator was used in order that the whole machine might be cooled down to the temperature of melting ice. A quantity of milk was then weighed and the time noted which it required to pass through the aerator; the temperature of the milk being taken, both before and after the aeration. The details of the tests are shown below.

TABLE XI—CHAMPION AERATOR.

Date	Temp. milk before. F.	Temp. milk after. F.	Milk. Lbs.	Minutes taken.	Pounds aerated per hour.
April 27.....	92	67	23	5	275
" 28.....	92	63	25.5	8	190
" 29.....	92	57	16.5	6	165
" 30.....	86	61	23	7	197
May 2.....	92	60	19	5	230
" 3.....	94	64	22	6	220
" 9.....	91	62	29	6	290
" 10.....	91	60	23	6	230
" 16.....	92	64	21	5	250
" 19.....	91	63	20	5	240
Av'age	91	62			230

This aerator when kept filled with ice water will cool from 225 to 250 lbs. per hour down to the neighborhood of 60 degrees. The differences pointed out by the above figures seem to us to very

fairly indicate the relative merits of the two machines ; both are very nearly alike so far as ease of keeping clean is concerned. Where running water is not at hand we should prefer the Champion ; with running water, the Star.

The Powell Aerator is intended to aerate without cooling. We have found that air may be kept constantly bubbling through a forty quart can of milk as it is drawn from the cow for five minutes without cooling it more than two to four degrees.

Several tests of the keeping quality of milk that had been aerated by the several aerators and that which had not been aerated at all were made. From the milk as it came to the dairy house a half-pint bottle was filled. Different portions were then passed through the aerators and half pint bottles filled from them. These bottles uncorked were left exposed to the air in the work-room of the dairy house. Three times a day they were shaken and tested with litmus paper and by tasting until they were found to be perceptibly acid.

TABLE XII.—AERATION—KEEPING TEST.

Date.	Average temp. of room. F.	Champion.		Star.		Powell.		Not aerated.	
		Temp. milk when set. F.	Perceptibly sour. hrs.	Temp. milk when set. F.	Perceptibly sour. hrs.	Temp. milk when set. F.	Perceptibly sour. hrs.	Temp. milk when set. F.	Perceptibly sour. hrs.
April 27.....	57	67	69	50	72	88	69	92	69
" 28.....	55	63	72	49	72	90	64	92	64
" 29.....	54	57	63	52	63	88	63	92	63
" 30.....	60	61	63	56	63	82	63	86	63
May 2.....	68	60	25	51	39	90	39	92	39
" 3.....	72	64	26	56	26	92	21	94	21
" 9.....	61	62	44	50	44	89	39	91	39
" 10.....	65	60	44	53	44	89	39	91	39
" 11.....	63	62	62	52	62	89	44	94	48
" 16.....	64	64	39	53	39	90	25	92	25
" 19.....	63	63	39	53	39	85	39	91	39
Average.....			50		51		46		46

It will be seen that the milk aerated with the Powell Aerator kept no longer than that which had not been aerated. That

which was aerated by the Champion and Star aerators kept for a constant but not very long time longer than that which was not aerated. This difference in favor of the aeration is considerably less than we had expected to obtain ; but there were several conditions that are likely to have made this difference less than it would be under ordinary circumstances. In the first place the air in which the milk was set was comparatively uniform in temperature and free from contaminating odors ; in the second place only a short time elapsed after milking and aeration, so there was little chance for contamination in the stable. Then again all the surroundings of the cattle were kept as neat and clean as could well be done. We believe that under the conditions that affect most dairies the good effects of aeration would be more pronounced than those we obtained. But we are inclined to regard as extravagant the statement recently made, in a leading agricultural paper, that "aerated milk will keep at least three times as long as non-aerated."

The question is often raised whether milk that is intended for butter-making may be aerated and the cream afterwards successfully separated by the gravity process. Four trials were made in which the milk that had been aerated was set in Cooley cans at forty degrees side by side with milk of the same lot that had not been aerated. In all cases the temperature of the creamer was 40-44, and the milk set twenty-four hours. The results were as follows :

Aerated, av. per cent. of fat in skim milk	.53
Not aerated, av. per cent. of fat in skim milk.....	.31

It will be seen that while there was some loss in the efficiency of the creaming of the aerated milk, it was not very great. What is remarkable is that the aerated milk suffered no fall of temperature after it was placed in the creamer, and was more efficiently creamed than the diluted milk set at sixty degrees (Table I.), where the fall of temperature was 30-35 degrees. This seems to be in direct contradiction to the theory which supposes that the fall of temperature after the milk is set is one of the chief factors in complete creaming by the deep-setting gravity process.

HENRY H. WING.

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Cornell University Agricultural Experiment Station.

AGRICULTURAL DIVISION.

REMOVING Tassels from Corn.



By GEORGE C. WATSON.

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BULLETINS OF 1892.

38. The Cultivated Native Plums and Cherries.
39. Creaming and Aerating Milk.
40. Removing Tassels from Corn.

REMOVING TASSELS FROM CORN.

Since the publication of the results of an experiment made at this Station in 1890, in removing the tassels from corn to increase the yield, the experiment has been repeated and similar experiments have been made at experiment stations, in at least four other states, with varying results.

The numerous inquiries and correspondence received concerning these experiments seem to demand a more full explanation of the work done in this direction.

In one of the corn fields on the University farm, two adjoining plots were selected. Plot I. consisted of twenty-five rows of seventy-two hills each ; from each alternate row the tassels were removed soon after they appeared ; in many cases the tassels were yet quite well enclosed within the folds of the leaves at the time of removal, yet occasionally one would become well expanded and slightly polliniferous during the four days between pickings.

The tassels were removed by hand, as in the previous experiment, by giving an upward pull to the tassel causing the stalk to break some distance below and yet without removing any leaves.

Plot II. contained twenty-one rows of seventy-two hills each ; in this plot the tassels were removed from three-fourths of the rows ; that is, the tassels were left on the first row and removed from the second, third and fourth, left on the fifth and removed from the next three and so on, the last row of Plot I. forming the first row of Plot II.

The variety of corn was Sibley's Pride of the North. It was planted the last week in April in fertile, dry gravelly soil, in hills three and one-half feet apart in the row, and rows three feet eight inches apart. The first tassels were removed July 24, 1891, and on each of the following dates all tassels were removed that had made their appearance since the previous picking : July 28, Aug. 1, Aug. 7 and Aug. 15.

The corn was allowed to stand until fully ripe, as shown by the

total absence of any soft corn, when it was cut, husked, weighed and counted, with the results shown in detail in the following tables :

PLOT I.

	Num- ber of Stalks.	Number of Ears.			Weight of.		Weight of Stalks.
		Abor- tive.	Good.	Poor.	Good Ears.	Poor Ears.	
Row 1 Tassels left on.....	268	126	206	56	113.	14.5	221.
" 2 " removed...	274	163	211	78	109.5	20.	227.
" 3 " left on.....	281	117	202	72	110.	18.	214.
" 4 " removed...	264	168	208	60	111.	16.	214.
" 5 " left on.....	283	135	168	90	92.5	32.	223.
" 6 " removed...	278	208	204	72	107.5	21.5	204.
" 7 " left on.....	279	127	192	66	102.	19.5	199.5
" 8 " removed...	279	196	200	87	107.	27.5	203.5
" 9 " left on.....	268	124	194	80	99.	22.5	189.
" 10 " removed...	261	171	194	73	100.5	21.	174.5
" 11 " left on.....	303	137	135	68	109.	18.5	196.5
" 12 " removed...	271	197	192	86	100.5	22.	179.
" 13 " left on.....	278	137	198	77	105.	21.	179.5
" 14 " removed...	291	195	188	82	98.5	23.	184.5
" 15 " left on.....	287	145	194	79	104.5	22.	185.5
" 16 " removed...	284	196	196	89	99.	27.	189.
" 17 " left on.....	287	132	203	84	105.5	25.5	193.5
" 18 " removed...	289	237	202	88	105.	25.	188.5
" 19 " left on.....	293	147	204	80	109.5	25.5	195.5
" 20 " removed...	275	248	198	80	106.	22.5	201.5
" 21 " left on.....	280	155	211	69	109.5	21.	187.5
" 22 " removed...	289	232	203	85	105.5	28.5	.....
" 23 " left on.....	286	169	199	80	104.	21.5	196.
" 24 " removed...	264	212	196	90	97.5	26.5	185.
" 25 " left on.....	297	171	123	71	117.	19.5	209.5
Average Tassels left on...	284	140	187	75	106.	22.	199.
Average Tassels removed	277	202	199	81	104.	23.	196.

PLOT II.

	Number of stalks.	Number of ears.			Weight of.		Weight of stalks.
		Abortive.	Good.	Poor.	Good ears.	Poor ears.	
Row 1 Tassels left on.....	297	171	123	71	117.	19.5	209.5
" 2 " removed ...	298	212	222	72	116.	19.	202.5
" 3 " " ...	307	242	213	82	106.	24.5	203.5
" 4 " " ...	298	232	213	80	110.	20.5	190.5
" 5 " left on.....	263	144	197	71	99.5	19.5	260.5
" 6 " removed....	278	213	196	74	103.	20.	179.5
" 7 " " ...	294	220	192	79	99.5	21.5	158.5
" 8 " " ...	285	265	206	76	101.	21.5	172.5
" 9 " left on.....	272	176	202	58	101.	14.	163.
" 10 " removed ...	272	226	193	75	91.	20.5	155.5
" 11 " " ...	268	208	190	70	94.5	19.	148.
" 12 " " ...	272	257	198	64	99.5	17.	189.5
" 13 " left on	268	189	—	61	103.5	15.	170.
" 14 " removed ...	257	256	214	67	105.	17.5	174.5
" 15 " " ...	270	268	212	62	105.5	17.	168.
" 16 " " ...	282	245	210	75	104.	21.	173.5
" 17 " left on.....	271	174	216	55	104.5	14.	179.
" 18 " removed ...	279	254	216	63	110.	13.	169.5
" 19 " " ...	273	215	225	68	114.	18.	172.5
" 20 " " ...	290	251	220	78	109.5	20.5	165.5
" 21 " left on	270	163	192	67	100.	16.5	159.5
Average tassels left on...	274	170	186	64	104.	16.	190.
Average tassels removed	282	238	208	72	105.	19.	175.

The results of this experiment show that there was no marked gain from removing the tassels and no uniformity in gain or loss in yield with respect to the treated and the untreated rows, as many treated rows show a greater yield than untreated rows on either side and in many instances the reverse is true. This variation would probably have occurred had individual rows been selected at random from almost any part of the field. There is, however, quite a marked increase in abortive ears in the rows where the tassels were removed, over the rows where the tassels were left on, the increase being over forty per cent. and about the same per cent. of increase is noticed in each plot.

All "sets" that produced silk, and that did not produce grain, were counted as abortive ears; wherever a set produced grain, if only a few kernels, the set was counted as an ear.

The corn was cut, husked and weighed Sept. 29 to Oct. 4.

The synopsis of the results of this experiment are given in the following table with those of the experiment of the previous year.

	Comparative yield '91.		Comparative yield '90.	
	Tassels left on.	Tassels removed.	Tassels left on.	Tassels removed.
No. good ears.	100	109	100	151
No. poor ears.	100	110	100	141
No. abortive ears.	100	142	100	37
Total number ears.	100	121	100	88
Wt. good ears, lbs.	100	99	100	152
Wt. poor ears, lbs.	100	110	100	144
No. stalks.	100	98	100	101

On page 69 of Bulletin 20 of the Illinois Experiment Station, is given the following on the "Effect of Removing Tassels." "The tassels on alternate rows on four-tenths of an acre of Burr's white corn, were removed as soon as they appeared, each of the thirty rows was husked and weighed separately. The total difference between those having the tassels removed and those not removed was but one pound, thus showing no effect from removing tassels. In similar trials with sweet corn the yield was somewhat reduced when the tassels were removed."

The results of an experiment at Maryland Experiment Station in removing corn tassels, as published on page 359 of the Fourth Annual Report of that Station, gives the total average in pounds of corn from nine undisturbed rows as 247, and the total average in pounds of corn from eighteen rows with tassels removed as 223. And in an explanatory note concerning this experiment it is stated that "The greatest yield was at the rate of fifty-seven bushels of corn per acre and was from an undisturbed row. . . . It is found that in nine comparisons of rows side by side, only two of the rows with tassels removed exceeded in yield the undisturbed rows next to them. In seven cases the result was decidedly the other way. In this trial the result of removing tassels was unfavorable to the production of grain."

The following table, showing the yield of corn in a detasseling experiment made at the Nebraska Experiment Station, is a part

of the printed results on page 6 of the second appendix of Farm Notes in the Fifth Annual report of that Station :

Name of variety.	Color.	Yield per acre.	
		Tassels cut off.	Tassels normal.
Thomas	Yellow.	66.0	88.7
Yankee.....	Yellow.	51.1	76.4
St. Charles Dent.....	White.	63.3	78.7
Mammoth	White.	55.7	72.0
Mammoth Cuban.....	Yellow.	52.3	71.5
Centennial White.....	White.	81.6	87.1

An experiment in removing the tassels from corn at the Kansas State Experiment Station gave in brief the following results :

Total weight of ears from rows with tassels removed.....	1133.5
“ number “ “ “ “ “	1782
Average weight per ear from rows with tassels removed..	.636
Total weight of ears “ “ “ “ remaining	663.
“ number of ears “ “ “ “ “	1108
Average weight per ear “ “ “ “ “	.595
Yield in bushels from 2-20 of an acre “ removed...	16.19
Rate per acre.....	107.9
Yield in bushels from 2-20 of an acre, tassels remaining...	9.47
Rate per acre.....	94.7
In favor of removing tassels.....	13.2

"The corn was weighed in the field at the time of husking and not quite dry, which will account for the heavy yields as then indicated by the weight. But in any event it is here plainly shown throughout all the details, that there was a decided gain in the yield of corn by removing the tassels. It shows, also, that the individual ears on tasseled rows were heavier than on the rows where the tassels remained, and this in spite of the fact that the proportion of nubbins is somewhat the largest in the former. . . .

The tassels were removed from day to day as soon as they appeared.

There is nothing absurd in the idea that the removal of the tassel should increase the crop, provided tassels enough remain to fertilize all the ears. It is a well-known fact that the development of the floral organs is a great strain upon the plant and the

strength which is saved by this process may very naturally be directed toward the development of ears."

The results of the experiment at the Illinois Station and the one made here last year, practically show no gain or loss in corn production. The ones made at the Maryland and Nebraska Stations show a loss, while the Kansas experiment and ours of 1890 show a marked increase.

Wherever an increase in yield has been secured by removing the tassels, it seems to have been secured by removing them daily or as soon as they make their first appearance, that the object of removing the tassels is not accomplished whenever they are allowed to shed pollen or even expand. The failure to secure an increased corn production last year may be partially due to the long intervals between the dates of removing the tassels, although a greater tendency to corn production is shown by the marked increase in the number of sets in each of the good, poor and abortive ears, the total increase being above twenty per cent.

As the condition of the weather during the period of removing the tassels in the two years, and the amount of rainfall during the period of growth of the corn varied as greatly as did the results of the experiments, it is more than possible that these conditions influenced to a great extent the results. In 1890, during the months of July and August, the amount of rainfall, as shown by the records of the New York State Meteorological Bureau, was 5.53 inches with .42 inches during the period of removing the tassels (July 21, Aug. 4) while in 1891, during July and August, the rainfall was 7.69 inches with 3.80 inches during the period of detasseling.

During the former experiment, the corn apparently suffered on account of insufficient moisture which continued for some time after the tassels were removed, while last year, during the same period, there was abundant moisture.

To get some idea, if possible, of the amount of plant food lost to the plant, and given off in the form of anthers and pollen, the following test was made in the University corn field last year on the same variety of corn and under similar conditions as was the detasseling experiment.

Large paper bags were tied over the tassels before they had become expanded, the bags being of sufficient size to allow the tassel to expand, and were securely tied about the stalk to pre-

vent the escape of any pollen. These bags were tied on the stalks July 30 to Aug. 3 and taken to the Station Chemist, Mr. Harry Snyder, Aug. 13, who reported that an average of six stalks gave of anthers 7.02 grams and of pollen 3.49 grams. An analysis of the anthers and pollen gave the following composition :

ANTHERS.

	Per cent.
Water	24.56
Ash	4.73
Fat (ether extract).....	2.07
Crude fiber.....	14.49
Crude protein	14.27
Carbohydrates (N. free extract)	39.88
	100.00

POLLEN.

Water.....	27.27
Ash.....	2.13
Fat (ether extract).....	.94
Crude protein.....	17.11
Carbohydrates (N. free extract)	52.55
	100.00

Allowing the corn to be planted in hills three feet six inches apart each way, and three stalks to the hill, the amount and composition of pollen per stalk will give of nitrogen 2.25 lbs. per acre, and the anthers will give 3.76 lbs per acre, or 6.01 lbs. in all, which makes the loss of nitrogen to the plant very considerable, equal to a very liberal application of nitrogen in the form of commercial fertilizers. As the percentage of ash in both the anthers and pollen was inconsiderable, an ash analysis was not made, but the amount of phosphoric acid and potash could not have been very great.

GEORGE C. WATSON.

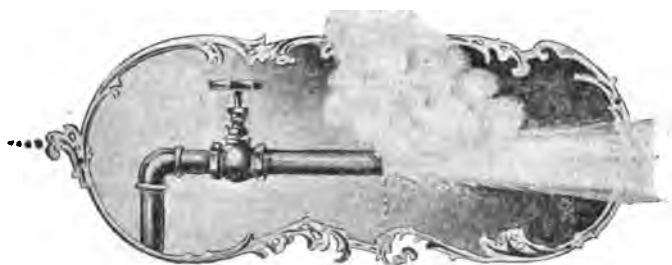
Bulletin 41.

August, 1892.

Cornell University Agricultural Experiment Station.

HORTICULTURAL DIVISION.

ON THE COMPARATIVE MERITS OF
Steam and Hot Water
FOR GREENHOUSE HEATING.



By FRED W. CARD.
WITH
Introduction by L. H. Bailey.

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BULLETINS OF 1892.

38. The Cultivated Native Plums and Cherries.
39. Creaming and Aerating Milk.
40. Removing Tassels from Corn.
41. On the Comparative Merits of Steam and Hot Water for Greenhouse Heating.

INTRODUCTION.

The following discussion of some of the comparative merits of steam and hot water for greenhouse heating is adapted from a thesis prepared for a bachelor's degree by Fred W. Card, who is at present a Fellow in Horticulture. The inspiration of the thesis lay in the facts that the subject itself is now much discussed by greenhouse men, and that the few experiments which have been made seem to consider chiefly but one item—the coal consumption—in the merits of the two systems. If we are to arrive at definite results concerning the relative merits of steam and hot water for warming glass houses, we must consider not only the consumption of coal, but the original cost of the systems, their adaptations to particular purposes, and comparative ease with which they can be managed. At the outset of our investigation we asked ourselves the question, "Where is the heat expended in the two systems?" It is evident that two heating plants which make the same amount of heat and carry it throughout houses of equal size may distribute this heat differently, and therefore vary widely in usefulness. We have endeavored to ascertain how much heat left the heater and how much returned to it, how much was expended near the heater and how much was carried to the farther end of the runs, how much escaped from the risers as top heat and how much from the returns as bottom heat. These questions, and many others, cannot be studied by taking the air temperatures of the houses. In fact, air temperatures taken at stated intervals seldom afford a satisfactory measure of the actual conditions of the houses, for they do not show the incidental variations, and they often overlook the temperature at the most critical period¹ of this fact is well illustrated in the air records of our houses in the following pages, which give the highest average for the hothouse although it was actually the coldest. It is apparent that air temperatures are influenced by sun, ventilation, water and plant general management, and they are discontinuous; the high shows

not, therefore, be accepted as accurate measures of the heating capacity of any apparatus. It follows that the performances of two systems can be studied nearly as well in houses of different construction as in similar ones, for the house is to a certain extent eliminated from the problem and the actual work of the apparatus is considered. The heat must be measured in and on the pipes ; after it leaves them it is largely beyond our control. And the dissimilar houses present the actual conditions of commercial establishments better than the others.

All our experience emphasizes the greater value of steam, but it must be understood that we do not condemn hot water. Steam is certainly better for our conditions, and we believe that it is superior for very large houses where the fall is slight, for most forcing-houses, and for all establishments which are likely to be often modified and extended. For conservatory purposes, for straight runs and small houses, it is perhaps equalled—possibly surpassed in some instances—by hot water. Steam overcomes obstacles, as elbows and angles and obstructions, better than hot water. It travels faster and farther. Crooked runs with little fall are great difficulties in hot water heating. Steam can be varied more quickly than hot water. On the other hand, steam is as steady as hot water under proper management, and it requires no more attention. In our own experience, the same treatment is given both heaters. Plants thrive as well under steam heat as under hot water heat. The opinion that steam heat is a “dry heat” is erroneous.

Hot water heating demands from a third to a half more piping than steam heating, and the original cost is therefore greater. This additional piping has a certain advantage, however, inasmuch as each pipe is less hot than in steam systems and is less likely to injure plants which stand close to it. This advantage is not great, however, especially in forcing establishments where no injury need ever come from hot steam pipes. In this connection it may be said that hot water for forcing establishments is most satisfactory when conducted in wrought iron or gas pipes, in exactly the same manner as steam. It remains to be said that for houses, comprising over 6,000 square feet and described above, we shall in the future use steam heat from a horizontal boiler.

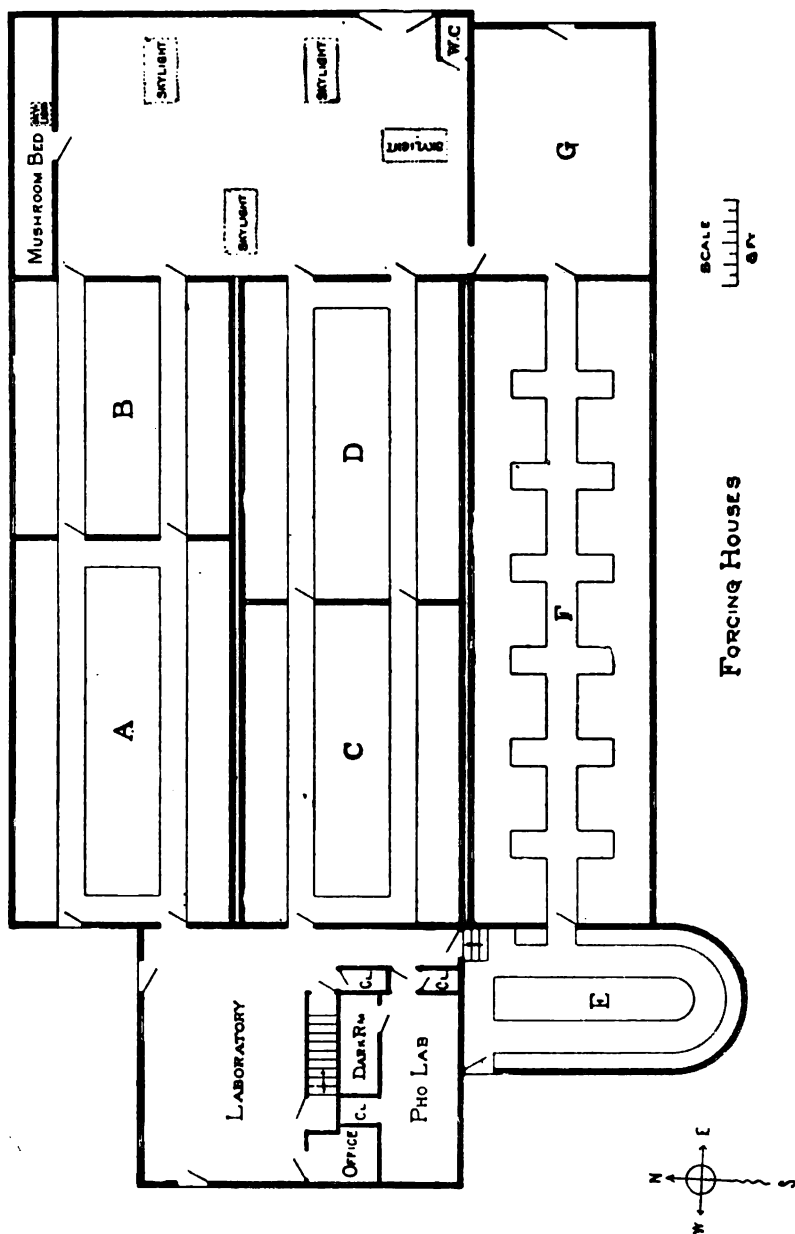
L. H. BAILEY.

ON THE COMPARATIVE MERITS OF STEAM AND HOT WATER FOR GREENHOUSE HEATING.

I. EXPERIMENTS AT CORNELL.

The question of the comparative merits of steam and hot water for heating horticultural buildings has received much attention from practical men. Experiments have also been made by Professor Maynard, of Massachusetts, and Professor Taft, of Michigan, in comparing the coal consumed and the temperature obtained in houses of similar construction, with all the conditions as nearly alike as possible. The object of the present observations was to learn, if possible, something more concerning the workings of the two systems, which should have a practical bearing on the subject.

1. *Methods. General records.*—These experiments were made in the University forcing-houses, a ground plan of which is shown in the diagram, Fig. 1. A B is a low house 20x60 feet, with three-fourths span, the north walk and benches being higher than those on the south side. It is a cool house, used mainly for lettuce and radishes, and is divided into two apartments by a board partition. It has a roof pitch of about 22° on the south side and $26\frac{1}{2}^{\circ}$ on the north side. In the second series, which has the same ground area, house C has a steep roof with the gable 11 ft. above the walk. The south slope of this house C is at an angle of some 40° , and the north slope about 42° . The roof of house D has an angle of nearly 31° on the south, and 39° on the north side. A cross-section of this house is shown in Fig. 2, page 120. Both houses have a three-fourths span with lower benches on the south side. C is used principally for tomatoes, D for cucumbers and beans. House E is ornamental or conservatory attachment, with glass sides and gable roof. F is a laboratory house 16x60 feet., about 9 ft. high a^{bove}



gable, having an even span with a roof slope of about $38\frac{1}{2}^{\circ}$. G is a continuation of the same structure, but has a lean-to hip roof. It is 16x24 ft. It is without benches, separated from F by a glass partition, and is now covered with cloth, being used as a cool propagating house.

The boilers are located near each other in the cellar, under the room marked Laboratory, in the plan. The steam heater is a No. 6 Furman, made by the Herendeen Manufacturing Company of Geneva, N. Y., a low pressure boiler which, according to the manufacturers' estimate, contains 175 sq. ft. of heating surface. The hot water heater is one made by the Lansing Engine and Iron Works and contains 175 sq. ft. of heating surface. The water is forced through the pipes by the pressure of an expansion tank standing 14 feet above the heater. The steam boiler heats the north and middle series (A B, C D), and the mushroom pit. Pipes also run into the photograph laboratory and to a small radiator in a living room over the Laboratory. Two 2-inch overhead risers carry the steam from the heater, one riser supplying the series A B, and the other the series, C D. The return from each riser is carried by seven $1\frac{1}{2}$ -inch pipes, there being two under each side bench and three under the center bench. Fig. 2 shows the method of piping. The riser will be seen near the peak and the seven returns under the benches. The hot water plant heats the house E, containing some 350 sq. ft., the lower house F, and the cloth house G. A coil also runs into the workroom at the rear, but practically very little heat gets into this. Four 2-inch risers carry the hot water, two overhead risers supplying the long house F, one the house E, and one the cloth house G. Observations on the hot water plant were taken only in one run in the long house F. The returns in this case comprise a vertical coil of six $1\frac{1}{4}$ -inch pipes connected at the extremities by manifold tees, and passing under the bench. At the boiler end this coil is condensed into two $1\frac{1}{4}$ -inch pipes, one taken from the top of the manifold tee and one from the bottom. It is interesting to know that the average temperature is 11 degrees higher in the upper one of these pipes, showing that the return water preferred that pipe. The riser for house G passes under the benches of house F. Common wrought iron pipes are used throughout the establishment.

The various character of these houses necessitates many elbows

and fittings in the piping and the fall is slight; these are conditions to which water is not adapted. But as these are the conditions which are usually present in commercial establishments, our results must have an intensely practical bearing. Steam overcomes difficulties much more readily than hot water. Our hot water system is put in after the most approved fashion, and the following tests concern the actual merits of the two systems under practical conditions. In perfectly straight and simple runs, the results might be very different.

The observations were made by inserting thermometers near the boiler inside the riser and return of each series of houses, and placing others on the outside of the risers at the extreme ends of each series. Table I shows the temperatures at all these points, morning and night, from Jan. 18 to Feb. 29, 1892, together with the steam pressure, if any, the outdoor temperature, and the temperature of each of the houses. It should be borne in mind that houses A and B are purposely kept cool, for growing plants requiring a low temperature. The ventilators were often open, as noted by the letter V in the table, while the doors between the cool workroom and both steam series were generally open. These conditions would lower the average temperature shown by these steam houses. The thermometers used for the inside temperatures were let into the interior of the steam pipes through a fourth-inch tap or hole, and were made tight by a filling of putty; they remained permanently in this position during the whole experiment. These were glass thermometers of very delicate make. Those used on the outside of the pipes were placed so that the bulb rested on the pipe, the bulb being imbedded in a ball of putty to offset the effect of air temperatures as far as possible. These were placed on the risers at opposite ends of all the houses, and are the ones corresponding to letters A, B, C, D, E, F, in the following table. These thermometers stood in the houses indicated by their letters: A, B, C, D, in houses A, B, C, D, respectively, or the steam houses; E, F, in the hot water house F, E being at the west or boiler end and F at the farther end. The thermometers inserted inside the pipes are designated by small letters, to correspond with the respective series of houses. Part of these latter are in the risers and part in the returns, as indicated in the table. These inside riser thermometers were inserted near

the heater, before the riser entered the house; and the return thermometers were inserted near them or after the pipes had left the house.

Return thermometer a b is inserted in the pipe which takes the return from the middle and upper benches of house A and B; those from the lower bench passing back by a separate pipe to the general steam return. Return thermometer c d is in the pipe which carries the return from all the runs of house C and D. The mercury in this thermometer was occasionally found to fluctuate back and forth with a comparatively uniform and rapid motion. Whenever this was the case, the figures are given which show the extent of the range. This thermometer being in the return near the boiler, there was probably a backward pressure at times, forcing some of the heat into the return, which at this point is below the water level in the boiler, and nearly horizontal. A slight tendency to a similar action was noted in the other series once or twice (return a b) but that thermometer is in an upright portion of the return, nearly as high as the top of the boiler, where such an effect was not to be expected.

It will be seen by the table that on the mornings of Feb. 23, 24, 25, 26 and 29, there was practically no circulation in the pipes of houses C and D. These were warm mornings and the fires were low, hence in computing the averages of the thermometers on this run more reliable figures are obtained by disregarding these observations, and such modified figures are used in comparison in the summary of Table I, although the actual averages obtained by including these are also given in parentheses. This is of little importance in the return, where the temperature is changeable, for it there modifies the average but slightly.

TABLE I.—GENERAL TEMPERATURE RECORDS.—JAN. 18-31, 1892.

Date.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	31.
Time of day	5:30	8:45	5:20	8:20	5:30	8:20	5:30	8:15	5:30	8:20	5:30	8:20	5:30	8:30
Steam pressure.....	—	—	—	3	0	0	0	0	1½	½	0	0	0	0
Riser, a, b.....	210	210	210	217	210	210	210	210	212	217	222	213	220	213
Riser, A.....	191	192	192	199	192	192	189	190	195	192	193	197	203	195
Riser, B.....	182	182	182	181	187	182	181	181	184	183	186	184	184	188
Return, a, b.....	172	180	152	112	209	184	160	153	180	183	195	201	200	210
Riser, c, d.....	210	210	210	211	218	211	211	211	212	218	224	214	221	214
Riser, C.....	195	195	195	194	198	196	196	192	197	198	198	205	196	200
Riser, D.....	190	190	189	189	197	189	191	189	190	193	193	191	195	199
Return, c, d.....	92	137	128	170	162	116	116	127	84	142	137	159	166	143
Riser, f.....	145	175	173	174	180	165	181	145	162	176	188	159	150	137
Riser, E.....	122	153	149	152	162	146	162	126	141	153	162	143	134	124
Riser, F.....	101	142	134	142	153	134	152	108	127	143	156	137	120	107
Upper return	108	135	138	137	146	125	144	105	126	138	145	133	121	107
f, (see p. 111)	99	123	125	125	134	119	131	96	118	126	132	121	111	97
Lower return, f.....	32	18	13	—9	3	13	21	26	32	34	27	30	32	33
Outdoor tem	House, A.....	60	59	60	52	64	62	59	60	64	70	64	70	66
House, B.....	61	59	60	54	65	64	56	61	56	63	72	62	80	77
House, C.....	58	60	59	59	68	66	68	63	60	71	69	79	72	69
House, D.....	58	62	57	52	61	61	61	58	60	68	64	72	68	63
House, F.....	58	62	67	62	68	65	68	58	67	76	68	77	69	64

LEGEND.—Capital letters indicate temperatures on the outside of the risers. Small letters indicate temperatures inside the risers and returns. A, B, C, D, a, b, c, d, refer to steam temperatures in all cases, and E, F, e, f, to hot water temperatures. The letters, except E, e, also correspond to the respective houses.

TABLE I.—GENERAL TEMPERATURE RECORDS.—FEB. 1-13, 1892.

Date.	1.	2.	3.	4.	5.	6.	8.	9.	10.	11.	12.	13.
Time	8:30	5:20	8:30	5:20	8:30	5:20	8:30	5:20	8:30	5:20	8:30	5:20
Steam Pressure	0	0	0	0	0	0	0	0	0	0	0	0
Riser, a b.....	210	210	210	210	210	210	210	210	210	210	210	210
Riser, A.....	192	192	192	192	192	192	192	192	192	192	192	192
Riser, B.....	181	181	181	181	181	181	181	181	181	181	181	181
Return, a b.....	109	147	105	200	105	200	105	175	152	108	182	204
Riser, c d.....	210	210	210	210	210	210	210	210	210	210	210	210
Riser, C.....	196	196	195	202	194	199	195	195	195	194	196	194
Riser, D.....	191	190	190	197	191	194	191	191	191	192	189	192
Return, c d.....	60	71	150	72	152	84	105	125	99	105	176	105
Riser, f.....	129	161	146	191	140	173	151	146	147	155	163	182
Riser, E.....	116	146	120	136	123	152	133	132	130	138	142	158
Riser, F.....	113	128	118	148	110	130	112	114	112	117	121	138
Upper Return, f	103	127	121	151	114	139	118	117	110	119	123	141
Lower " f	94	116	08	135	112	126	107	105	99	107	110	125
Outdoor Temp.	34	37	38	42	28	31	31	28	21	17	5	24
House, A.....	64	68	67	72	58	68	64	62	56	50	58	65
House, B.....	68	68	48	68	62	69	70	65	64	56	58	71
House, C.....	66	73	65	70	60	76	65	68	60	54	66	68
House, D.....	65	68	65	66	64	68	65	64	60	60	54	65
House, F.....	66	70	69	70	60	73	67	62	60	59	60	69

Pipe Readings.

Air Readings.

TABLE I.—GENERAL TEMPERATURE RECORDS.—FEB. 15-29, 1892.

Date.	15.	16.	17.	18.	19.	20.	22.	23.	24.	25.	26.	27.	29.
Time.....	8:30	10:	8:30	8:	8:20	8:15	8:30	8:30	8:30	8:30	8:30	8:30	5:30
Steam pressure.....	$\frac{1}{2}$	2	0	0	0	0	0	0	0	0	0	0	0
Riser, a b.....	211	214	210	211	211	210	210	210	210	209	210	211	209
Riser, A.....	193	192	192	193	192	192	191	192	188	190	188	192	191
Riser, B.....	183	186	179	184	182	183	186	179	180	178	186	182	184
Return, a b.....	191	186	176	185	205	198	199	191	142	175	211	160	109
Riser, c d.....	212	215	211	212	212	212	210	210	210	205	174	214	210
Riser, C.....	195	202	197	200	200	198	196	200	197	198	194	195	198
Riser, D.....	192	195	191	192	188	191	192	191	192	196	86	194	190
Return, c d.....	153	92	133	167	170	170	170	109	106	142	109	141	80
Riser, f.....	121	128	157	172	122	170	123	135	144	143	162	141	141
Riser, E.....	110	112	140	152	105	155	108	128	130	140	146	130	122
Riser, F.....	113	108	121	136	90	156	94	102	114	128	127	112	106
Upper return, f.....	105	98	122	131	92	110	92	110	115	123	129	110	107
Lower return, f.....	95	86	110	120	81	102	82	98	104	116	118	100	96
Outside temp.....	26	18	14	14	12	16	30	33	34	38	40	36	32
House tempera- ture A.....	67	56	68	55	66	58	67	62	70	62	62	70	56
House tempera- ture B.....	68	55	46	59	56	52	63	66	71	64	58	72	58
House tempera- ture C.....	66	60	79	58	74	60	73	66	66	64	65	71	63
House tempera- ture D.....	65	64	64	58	64	60	64	65	65	60	63	68	58
House tempera- ture F.....	64	60	65	60	63	64	56	61	68	62	68	66	62

Pipe Readings.

Air Readings.

SUMMARY OF TABLE I.

Steam.	Riser, a b.....	Average for the whole time, 211°			
	Riser A.....	"	"	"	193°
	" B.....	"	"	"	183°+
	Return a b.....	"	"	"	160°
	Riser c d.....	"	"	"	(208) 212°
	" C.....	"	"	"	(191) 196°+
Hot water.	" D.....	"	"	"	(185) 192°
	Return c d.....	"	"	"	(131) 130°
	Riser, f.....	"	"	"	155°+
	" E.....	"	"	"	137°
	" F.....	"	"	"	124°
	Upper return, f.....	"	"	"	122°
	Lower " f.....	"	"	"	111°

These figures show that the average temperature of the steam pipes, during six weeks of mid-winter, was much higher than that of hot-water pipes. We must now endeavor to ascertain how much of this greater heat was efficient in heating the houses, how it was related to the practical care and management of the establishment, and how much it cost.

2. *Radiation from the pipes.*—It is necessary at the outset to find out how much of the interior heat in the pipes—in both systems—passes into the atmosphere of the houses as warmth. This is done by a study of outside and inside pipe temperatures, after the method already explained. The methods of obtaining the outside pipe temperatures are necessarily somewhat questionable. If the thermometer bulbs were simply placed against the pipes without being covered, the readings would be very much subject to fluctuation from the effect of air temperatures, and they are doubtless somewhat so by the present method. It is probable, however, that on the whole they give a reasonably fair measure of the heat given off at those points. In order to determine as nearly as possible the relation between the inside temperatures and those obtained on the outside, a thermometer was placed on the outside, at the point where riser thermometer c d was inserted in the pipe, and two on the hot water riser near the point where riser thermometer f was inserted. All the steam risers are painted, while those carrying hot water are not; in order to obtain uniform results, a portion of the hot water pipe here was painted two coats, and one thermometer was placed on this, the other on the unpainted surface.

The average difference between inside and outside tempera-

tures in the steam riser at times when there was a free circulation was about 22° , with an inside temperature of about 214° . The average difference in the hot water pipe where painted was 5.9-14 degrees, unpainted $4\frac{1}{2}$ degrees, with an inside temperature in each case of nearly 122° . This indicates that painted pipes radiate slightly less heat than unpainted ones. The great difference between the steam and hot water pipes is probably due to the higher temperature and more rapid motion of the steam. Consecutive observations on the steam riser made at a time when the steam was going down gave the following comparisons :

Inside temperature...	147°	130°	120°	110°	100°	90°
Outside “ ...	137	122	114	106	98	89

These figures show that the greater the pressure—or the inside temperature—the greater is the proportionate difference between outside and inside temperatures. The outside temperature may be taken as the radiating or warming power of the pipe, and whatever difference there may be between the outside and the inside, represents the amount of heat which is carried further on. This greater difference under increasing pressure is due, apparently, to the more rapid circulation of the steam at such pressure by which proportionally less is given off at any one point, it being distributed over a greater length of pipe. This rapid movement is therefore an important advantage which steam possesses over hot water for heating long houses.

The very few other observations obtained on the steam riser at low temperatures indicate that this relation between outside and inside temperatures is reasonably uniform. The range of inside temperatures from which comparisons were obtained in the hot water pipes was much more limited, but there does not seem to be such a uniform difference between outside and inside readings with increase of temperature as with the steam. The results in Table I. plainly show a considerable variation at different points between the outside and inside temperatures, but how much of this is due to differences in painting, radiating powers of the pipes, etc., and how much to the crudeness of the method, it is impossible to say. Thermometer riser A shows a temperature differing not more than 18° , on the average, from that of the inside of the pipe ; that on riser C shows 16° variation from the inside temperature, but as there was a distance of some 20 ft. between this and

its twin inside thermometer c d, the real difference is probably not more than 15 degrees.

It is evident, from this study of radiation, that the higher the inside temperature the less is the proportionate warming power of the pipe at a given point; and as a higher temperature and more rapid flow are ordinarily carried with steam than with hot water, steam has the advantage in carrying long runs. It is said, however, that much of the fierce heat of rapidly moving steam is returned to the heater and is lost as a direct warming agent; but this depends entirely upon the length of the run. It is to be expected that the relative merits of steam and hot water for greenhouse heating depend very much upon the sizes and shapes of the houses, and it is surprising that these conditions are so little considered. The distribution of heat in our two systems should now be discussed, for it will throw much light upon the whole question.

3. *Distribution of heat in the pipes.*—We will now compare the temperatures at extreme ends of the different systems, both in risers and returns, in order to determine where the heat is transferred to the atmosphere of the houses. Table II. shows the average temperatures, during the whole time, inside the risers and returns, and on the outside of the risers, at opposite ends of the houses. The inside thermometers in all the risers, and in the returns from the steam houses, were about 12 ft. from the heater; those in the hot water returns were some 20 or 25 ft. from the heater.

TABLE II.—AVERAGE PIPE TEMPERATURES.

Riser a b—Average inside temperature.....	211°
“ A— “ outside “	193°
“ B— “ “ “	183°+
Return a b—Average inside “	160°+
Riser c d—Average inside temperature.....	212°
“ C— “ outside “	196°+
“ D— “ “ “	192°—
Return c d—Average inside “	131°
Riser f—Average inside temperature.....	155°+
“ E— “ outside “	137°
“ F— “ “ “	124°+
Upper return f—Average inside temperature...	122°
Lower “ f— “ “ “ ..	111°

By a comparison of these averages it is seen that the loss of heat in passing the whole length—some 60 feet—of the steam series A B averages 10 degrees, and owing to the fact that the thermometer at the farther end showed an error, the difference is probably even less than this. Frequently when there was steam pressure of three or four pounds the entire circuit of about 150 feet was made with a loss of only 10 or 11 degrees. The average loss between the opposite ends of series C and D—which is a warmer run—was only slightly more than 4 degrees. Allowing 15° to 18° for the difference between outside and inside measurements at the last end, it is seen that in the returns there is an average loss of about 40 degrees between the farther extremity of the house and the heater, although this difference is not at all uniform.

In the tomato and cucumber houses, C and D, heated by steam, the figures used, as before stated, are those obtained by disregarding the observations on the mornings of Feb. 23, 24, 25, 26 and 29, when there was practically no circulation in this run of pipes. Here the average difference between the registering of the ther-

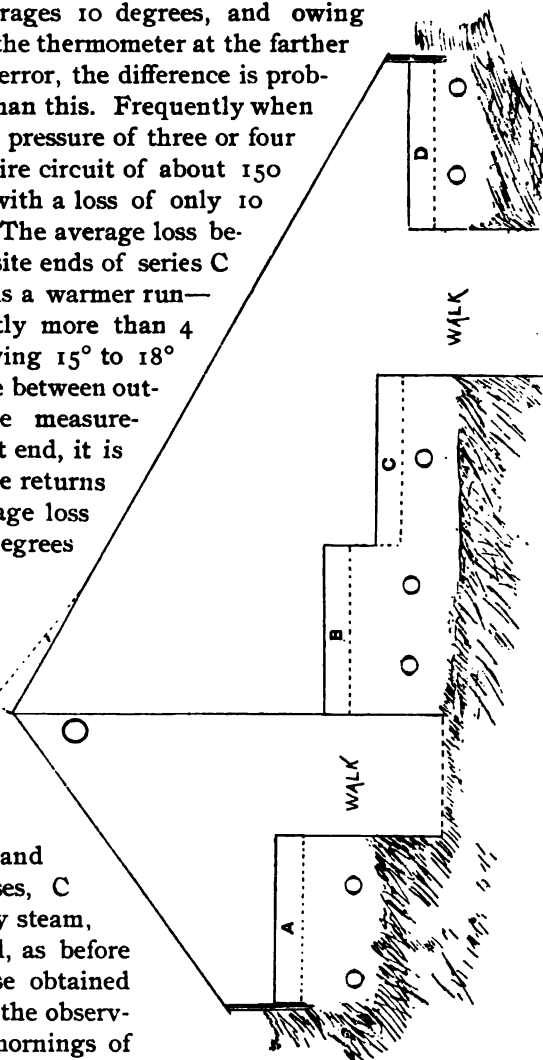


FIG. 2.—Cross-Section of House D. Scale one-fourth inch to the foot.

mometers inserted in the riser, and the first one outside, is only 16 degrees, although a distance of some 20 ft. or more is passed over between them. The average loss shown in the riser in passing the length of the two houses is only a trifle over four degrees, while in the return to the heater it averages some 75 degrees. This loss is much greater in proportion to the number of square feet of radiating surface in the returns than in the risers, yet it can hardly be said that the returns are more efficient in radiating heat. The greater loss in the returns of C and D than in those of A and B is approximately proportional to the number of square feet of radiating surface in the returns of C and D, as those of A and B condense into a single pipe, into which the thermometer was placed. This may indicate that the heat lost in the returns is radiated from the pipes in proportion to the surface, although it is impossible to say that this is the fact.

In the hot water house we find that the water leaves the heater at an average temperature of 155° and comes back at a temperature of 122° by the upper return and 111° by the lower return. There is an average loss of 13 degrees in passing the length of the house. If we assume that 5 degrees is a fair average for the difference of outside and inside temperatures at the west end and four degrees at the east end, it indicates a loss of 13 degrees from heater to the first end of the house—nearly 20 feet—13 degrees in passing the length of the house, 60 feet, 6 in the upper return and 17 in the lower return.

It is seen that in the steam plant the heat is nearly uniform throughout the whole length of the riser, being carried to the farther extremity of the houses with a loss of 4 to 10 degrees, while the hot water riser loses about 25 degrees in passing to the farther end, although on account of its location this point is some 20 ft. farther from the heater than the end of the steam house, C & D. In the hot water plant the variation in temperature between the point of leaving and the return to the heater is much less than with steam, but Table I shows far more irregularity in the comparative temperatures at different points, while as a rule more is lost in the riser than in the return. This shows plainly the superiority of steam for long distance heating and for purposes of bottom heat. The heat can be forced the whole length of the riser with comparatively little loss and be distributed

throughout the returns to be given off where it is most needed ; and the steam gives us a greater uniformity of temperature throughout the houses, as is well shown in Table III.

The following table shows the extreme variations in the difference of temperature at the opposite ends of the houses at any one time, disregarding the mornings before mentioned ; also the extreme fluctuation at each point, during the whole time :

TABLE III.—FLUCTUATION.

Fluctuation in difference between thermometers riser E and F. 12 less to 22 more, or 34° (Av. difference 13°).

Fluctuation in difference between risers C and D. 1 to 10° , or 9° . (Av. difference 4°).

Fluctuation in difference between risers A and B. 2 to 15, or 13° . (Av. difference 10°).

Fluctuation in riser A, during test.....	189 to 203 or 14°
“ “ without pressure....	189 to 195 or 6°
“ “ B, during test.....	180 to 192 or 12°
“ “ C, “	180 to 205 or 25°
“ “ D, “	179 to 202 or 23°
“ “ E, “	105 to 180 or 75°
“ “ F, “	79 to 164 or 85°

It is seen that while the riser at the west end of the hot water house, E, averaged 13 degrees higher than the one at the east end, F, it was in one case 12 degrees lower and the extreme difference in the opposite direction was 22 degrees, or a fluctuation of 34 degrees, while that between opposite ends of the steam houses is much less, being only 4° in the warm houses, C and D. Another surprising point is the great variation in temperature at a given point in the hot water riser, averaging over four times as great as that of steam. Of course the steam temperatures, if taken in the middle of sunny days, or at any time when there was little or no circulation, would show a greater diversity than this, but it is to be borne in mind that these are just the times when the houses are warm enough and no heat is needed from the pipes. The general observations show that the times when temperatures were lowest in the hot water pipes were not warm mornings when the fires were low, but cold ones when the steam pipes showed high temperatures and all the heat was needed. In all points, therefore, steam surpassed hot water.

4. *Coal consumption.* January 20th at one o'clock P. M. both

heaters were shaken down as usual leaving only a thin bed of fire in the box. All the coal used during the next two weeks was weighed. Table IV shows the outdoor temperature and that of the different houses, together with the averages during that time :

TABLE IV. TEMPERATURES DURING COAL TEST.

JANUARY.												
	20		21		22		23		24		25	
Time	5:30	8:15	5:30	8:30	5:00	8:20	5:20	10:30	5:00	8:15	5:15	
Outdoor Temp.....	3	13	21	26	32	34	27	30	32	33	37	
House " A.....	64	62	59	60	64	70	64	76	73	72	63	
" " B.....	65	64	56	57	63	72	62	80	77	76	61	
" " C.....	68	66	68	63	60	71	69	79	72	69	72	
" " D.....	61	61	61	58	60	68	64	72	68	68	63	
" " F.....	68	65	68	58	67	76	68	77	69	64	60	

JANUARY.												
	26		27		28		29		30		31	
Time	8:30	5:15	8:35	5:20	8:20	5:20	8:20	5:30	8:30	5:30	8:35	6:00
Outdoor Temp.	0	6	8	15	20	30	29	37	36	34	28	32
House T. A.....	52	51	56	62	67	71	66	64	70	65	60	68
" " B.....	48	52	59	68	66	75	69	64	76	52	62	66
" " C.....	59	60	68	64	66	73	72	68	70	71	71	66
" " D.....	56	56	59	61	61	68	66	68	69	71	66	65
" " F.....	60	70	68	62	64	76	68	64	75	66	62	66

FEBRUARY.																
	1		2		3		Av.									
Time	8:30	5:20	8:30	5:20	8:30				} 65+ for steam. 67 for hot water.							
Outdoor Temp.....	34	37	38	42	28	26.5										
House " A...	64	68	67	72	58	64.5										
" " B...	68	68	48	68	62	64.5										
" " C...	66	73	65	70	60	68										
" " D...	65	68	65	66	64	64+										
" " F...	66	70	69	70	60											

The steam boiler consumed during this time 6,691 lbs. of coal, and the hot water boiler 5,251 lbs. The steam boiler heats about 2,500 square feet of surface. The hot water boiler heats about 1,700 sq. ft. The following comparisons are therefore obtained :

In surface heated,

Hot water : Steam :: 1 : 1.47—

In coal used,

Hot water : Steam :: 1 : 1.27—

This shows a consumption of about 15 per cent. more coal per 100 sq. ft. of surface heated by the hot water heater than by the steam heater. The average temperature is slightly higher in the hot water house than in the steam houses, but it was also more variable. In the colder parts of the night it went much lower, for twice during the winter plants were chilled in this house, while nothing of the kind occurred in the steam houses. As a matter of fact it has been difficult to maintain a suitable temperature in the hot water house whenever the weather was cold. These fluctuations in greenhouses are seldom indicated by observations taken at two or three stated intervals during the day. The space heated by the hot water causes considerable bending in the pipes, while the fall is rather slight, conditions which are unfavorable to water heating; for every curve and angle interferes greatly with the movement of water. The results indicate that while hot water may equal steam in simple and straight runs, it is not so well adapted to use under varying and unfavorable circumstances and in long houses. No definite conclusion as to the relative merits of the two systems as to coal consumption can be made from these observations, for the conditions are not such as to give a genuine comparison. But they are an indication that steam is more economical under the conditions here present; and our conditions are similar to those of most commercial forcing establishments.

It is impossible to determine whether this saving of coal in our steam plant is due to greater economy of steam as compared with hot water, or to mechanical differences in the two heaters. Fowler* considers steam cheaper than hot water in coal consumption, chiefly because excess of heat is shut off in the steam pipes, and steam heaters are commonly provided with automatic regulators. Our steam heater has an automatic regulator, while the hot water has not.

5. *Influence of pressure upon the temperature of steam pipes.*—While it is true that the greater the pressure indicated by the steam gauge, the more readily is the steam carried through long runs and past obstacles, the influence of this pressure upon the temperature of the pipes is not so obvious. Table V shows the influence of pressure upon the temperature of risers and returns:

*Hints on the Heating of Greenhouses, 31.

JANUARY.

A corresponding rise in temperature with increased pressure is shown, but it is not altogether uniform. It appears that the same temperature does not necessarily follow from the same pressure. The following figures, deduced from the results, furnish a rough estimate of the influence of pressure on the temperature inside the risers at this distance, about 12 ft. from the boiler :

It is to be noted that in general, pressure increases the temperature of the returns much more than of the risers. The return from A and B in nearly every case of pressure shows a temperature higher than its general average at that point, while the exceptions are but few in the return from C and D. The return from A and B is direct, uniting but two of the runs of these houses, while that from houses C and D is from a slightly longer circuit, and unites all the runs, so that doubtless more of the steam is condensed in this latter case before reaching the point where the thermometer is inserted. Its lower general average indicates this.

These figures give conclusive evidence of the utility of pressure in forcing circulation through long circuits. They also suggest a question as to the economy of maintaining such a pressure as to keep up a rapid circulation. It is evident that the condensation of the steam in the returns liberates its latent heat where it must be available in warming the houses. Whether this makes a better use of the heat than to return the steam to the boiler uncondensed, allowing it to be again sent into the circuit without the expenditure of fuel necessary to the production of this latent heat, may be a question. The general observations show that there is usually a higher house temperature with steam pressure, when the outdoor temperature is about the same. It does not appear at all uniform, however, and the observations are not such as to give any satisfactory indications toward an answer to the question.

II. EXPERIMENTS ELSEWHERE.

It appears from the literature readily available, that the use of steam in closed circuits was invented by Mr. Hague in England about 1820*, although certain methods in which the steam passed off at the further end of the house, had been previously in use. At this time the construction of apparatus was such as to require almost constant attention to fires, in order to maintain the temperature. Frequent repairs were needed and explosions were common. The first trials with hot water were made by Anthony

* Trans. Lon. Hort. Soc. iv. p. 434.

Bacon and Mr. Atkinson in 1822.* These men worked independently, and both secured successful results.

The laws governing the circulation of hot water are carefully treated by Thomas Tredgold in a paper before the London Horticultural Society in 1828.† In 1840, John Rogers wrote, "On the whole there appears no doubt that the circulation of hot water in iron pipes is the best means hitherto devised for heating Horticultural Buildings."‡ This quotation probably represents about the consensus of opinion on the subject in England to the present day. One of the earlier promoters of this system was Charles Hood, author of "A Practical Treatise on Warming Buildings by Hot Water, and an Inquiry into the Laws of Radiant and Conducted Heat."

The use of steam for heating purposes began to receive marked attention in this country some fifteen years ago. In the discussions of the Society of American Florists in 1885, the average from estimates in answer to circulars by nearly fifty florists showed that one ton of coal with hot water heated 108 sq. ft. of glass to a temperature of $53\frac{1}{3}$ degrees, while with steam the same amount heated 149 sq. ft. to a temperature of $60\frac{3}{4}$ degrees. The proceedings of the society for 1886 contain two articles setting forth the advantages of steam and hot water respectively. The statements are based on individual opinion rather than on any comparative results. In the proceedings of the society for 1888 (Vol. iv. 118), James D. Raynolds gives a good comparison of the two methods from theoretical standpoints, his opinion being that steam is preferable.

So far as can be learned, the first really comparative test was made by Peter Henderson about 1885 or 1886.|| The trial was made with two houses of similar dimensions and construction, the one fitted with hot water boilers, the other with steam boilers of the same size. The coal was weighed and it was found that there was a saving of 25 per cent. in the house heated by steam, while the plants did equally well. A. B. Fowler, in a recent

* Trans. Lon. Hort. Soc. vii. 204.

† Trans. Lon. Hort. Soc. vii. 568.

‡ Trans. Lon. Hort. Soc. 2d series, ii. 364.

||Proc. Soc. Am. Florists, Vol. ii. 107.

pamphlet on greenhouse heating, concludes that steam is preferable to hot water.

In the summer of 1888 two houses were constructed at the Massachusetts Experiment Station as nearly alike as possible, with boilers of the same make and pattern, one fitted for steam, the other for hot water. The following winter careful observations were made of temperatures and the amount of coal consumed. The results showed a saving of nearly 20 per cent. of coal in favor of the hot water heating, while the average temperature of the house was slightly higher. The temperature was also more uniform in the house heated by hot water. The test was repeated the following winter and showed a still greater advantage in favor of the hot water, there being a saving of over 30 per cent. in the coal consumed.

In the winter of 1889-90, a similar test was made at the Michigan Experiment Station with two houses of the same size and construction, and two boilers of the same make, having the same amount of grate and heating surface, and all other conditions as nearly alike as possible. The results agree with those in Massachusetts, showing a consumption of a little over 20 per cent. more coal by the steam boiler and a slightly higher temperature in the hot water house. These results are probably due to the simple and straight runs in these specially constructed houses.

The following is a list of references to the more important literature which bears on this subject. In general it includes only matter which deals with a comparison of the merits of the two methods:

1. Upon the Application of Hot Water in Heating Hot Houses—Thomas Tredgold, 1828. Trans. Lon. Hort. Soc. vii. 568.
2. Steam or Hot Water—James D. Raynolds. Amer. Florist, i. 46.
3. Steam vs. Hot Water—Alfred E. Whittle. Amer. Florist, i. 76.
4. Heating Greenhouses—Jos. H. Woodford. Amer. Florist, i. 235.
5. Hot Water Circulation—James D. Raynolds. Amer. Florist, iii. 62.
6. Steam Heating—W. H. Elliott. Amer. Florist, iii. 400.

7. The Heating of Greenhouses—E. S. Titus. Amer. Florist, iv. 223.
8. Steam Versus Hot Water for Heating—John Burton. Amer. Florist, v. 139.
9. Steam Versus Hot Water for Heating Greenhouses—John Thorpe. Proc. Soc. Amer. Florists, i. 56.
10. The Advantages of Hot Water over Steam for Heating Purposes—J. D. Carmody. Proc. Soc. Amer. Florists, ii. 107.
11. The Advantages of Steam over Hot Water—J. H. Taylor. Proc. Soc. Am. Florists, ii. 110.
12. Modes of Heating : Their Relative Cost of Construction and Operation—James D. Raynolds. Proc. Soc. of Am. Florists, iv. 118.
13. Bau und Einrichtung der Gerwächshäuser—Carl David Bouché and Julius Bouché, p. 304.
14. Greenhouse Building and Heating—L. R. Taft. Bulletin 63, Michigan Experiment Station.
15. Hot Water vs. Steam—Samuel T. Maynard. Massachusetts Hatch Experiment Station, Bulletins 4, 6 and 8.
16. Hints on the Heating of Greenhouses. Hot Water Heating. Low Pressure Steam Heating—A. B. Fowler. (Recent : no date).

CONCLUSIONS.

The results obtained lead to the following conclusions which are true under these conditions, although some of them may not be true universally :

1. The temperatures of steam pipes averaged higher than those of hot water pipes, throughout the entire circuit for the entire period of test.
2. The higher the inside temperature in steam pipes the less is the proportionate warming power of the pipes at a given point. The heat is distributed over a greater length of pipe, and as steam is ordinarily carried at a higher temperature than hot water, it has a distinct advantage for heating long runs.
3. When no pressure is indicated by the steam gauge, the difference between the temperatures of the riser and the return, is greater with steam than with hot water.

4. Under pressure, the difference is less with steam than with hot water.

5. There is less loss of heat in the steam risers than in the hot water risers, and this means that more heat, in the steam system, is carried to the farther end of the house and more is spent in the returns as bottom heat.

6. This relation is more uniform in the steam risers than in the hot water risers, giving much more even results with steam than with hot water.

7. When the fires are operative, the fluctuation in the temperature of the risers at any given point is much greater with hot water than with steam.

8. An increase in steam pressure raises the temperature of the entire circuit, but the temperature does not rise uniformly with the pressure.

9. The first application of the pressure increases the temperature of the returns much more than that of the risers.

10. Steam is better than hot water for long and crooked circuits.

11. Pressure is of great utility in increasing the rapidity of circulation of steam, and in forcing it through long circuits and over obstacles.

12. Unfavorable conditions can be more readily overcome with steam than with hot water.

13. Hot water consumed more coal than steam, and was at the same time less efficient. This result would probably be modified in a shorter and straighter circuit, with greater fall.

14. Under the conditions here present, steam is more economical than hot water and more satisfactory in every way; and this result is not modified to any extent by the style of heaters used.

FRED W. CARD.

Bulletin 42.

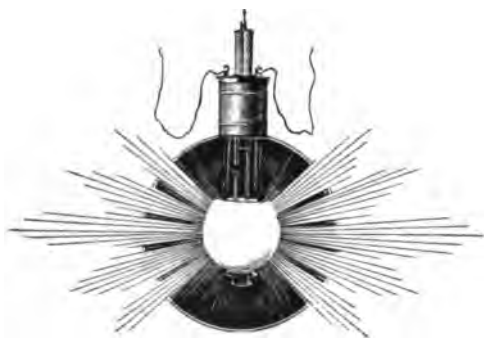
September, 1892.

Cornell University Agricultural Experiment Station.

HORTICULTURAL DIVISION.

SECOND REPORT UPON

Electro-Horticulture.



By L. H. BAILEY.

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BULLETINS OF 1892.

38. The Cultivated Native Plums and Cherries.
39. Creaming and Aerating Milk.
40. Removing Tassels from Corn.
41. On the Comparative Merits of Steam and Hot Water for Greenhouse Heating.
42. Second Report upon Electro-Horticulture.

SECOND REPORT UPON ELECTRO-HORTI- CULTURE.

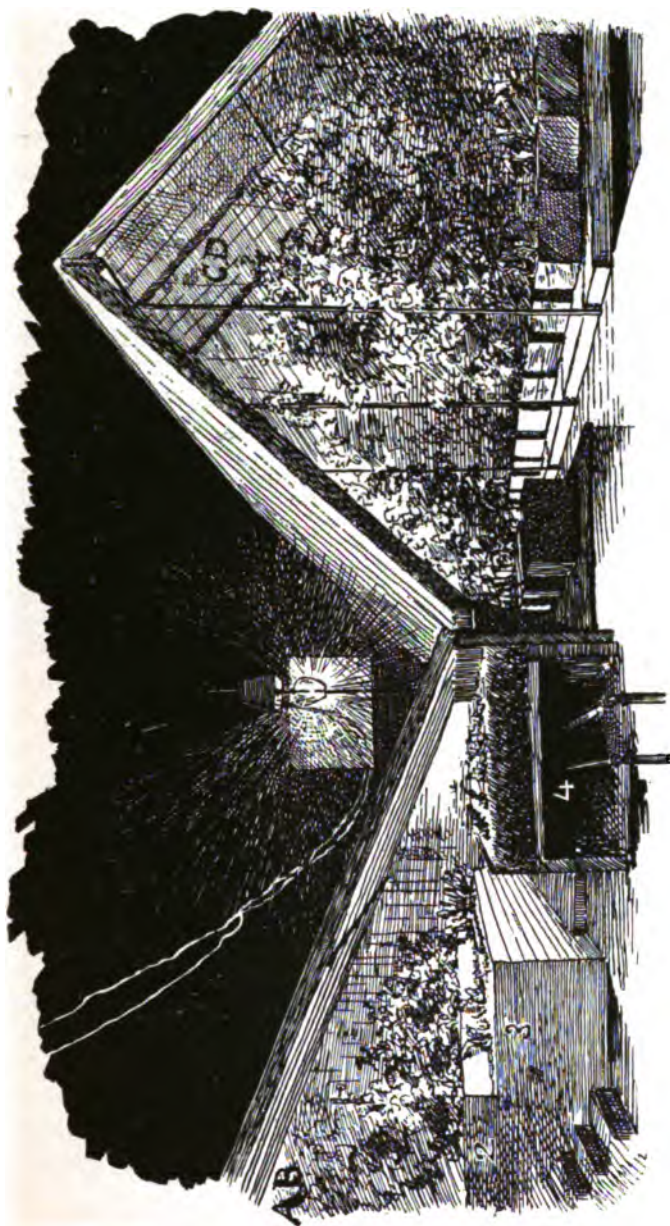
Beginning with the opening of the year 1890, a series of experiments was inaugurated upon some of the relations of electric lighting to plants grown in glass houses, and the results of the experiments for two winters were published a year ago (Bulletin 30). It was found that the electric light profoundly affects many plants, some injuriously and a few beneficially. Lettuce appeared to be greatly assisted by the light, and some ornamental plants produced earlier and brighter flowers under its influence. The experiments were all made with an arc lamp which hung inside the house, and it was found that better results were obtained when the arc was screened by an opal globe or even by a pane of window glass. The question at once arose if this screen could not be afforded with equal advantage by the glass roof itself if the light were hung above it; and if this were true, it must then be determined how far the beneficial effects of the light would extend, or, in other words, how much glass one light can cover. It is this particular point which the following paper considers. It may be said, in passing, that several other important investigations are in progress, but we are not yet ready to report upon them. Perhaps the most important of these investigations is one in which the light is passed through colored screens of known value, in order to determine what parts of the spectrum produce the singular results which we have observed.

We shall now consider, therefore, what are the effects upon a few common plants of an electric street-lamp suspended above a greenhouse. The arrangement of the experiment will be understood at a glance from the cross-section of the houses under discussion, on page 135. It will be noticed that there are two parallel houses; each is divided in the middle into two com-

partments. These houses are 60x20 feet. In the valley between these houses the lamp was hung, and the arc was six feet above the nearest glass. The lamp was hung in front of a large, blackened sheet-iron screen, which, in connection with the partition in the house and a series of curtains, completely excluded the light from the compartment behind the lamp. By moving the screen to the other side of the lamp and rearranging the curtains, we were able to throw all the light into the other compartment; this change was made during the experiment. The lamp is the same pattern as that used the previous winter,—a 10 ampere 45 volt 2000 nominal candle power Westinghouse alternating current lamp. The lamp was attached to an ordinary street lighting system, and it seldom burned after 11 o'clock, while it often ran but an hour or two, and on moonlight nights not at all. The lighted house was exposed to sunlight during the day, and in addition received this small and varying amount of electric light. The other or so-called dark house was lighted by sun during the day and received no light at night. The lamp carried a clear glass globe, so that the light passed through two planes of glass—the globe and the roof—before reaching the plants.

The upper house—comprising the compartments A and B—is what we term a cool house, and it was used for lettuce, endive, radishes, beets, spinage, cauliflower, violets and daisies. This is the house in which the experiments were mostly conducted, from the fact that the two compartments of the other house have unlike roofs and are therefore not comparable. These houses A B are the ones which were used in the experiments reported last year. Lettuce was grown on benches 1, 3 and 4; radishes upon the same, mostly between lettuce plants; beets upon 2; cauliflowers upon 3; and the other plants upon 2. Bench No. 1 is not shown in the illustration. The lower houses C D were used for tomatoes, cucumbers and beans; and as I shall not refer to those houses again, it may here be said that I was unable to detect any influence whatever of the light upon these three plants.

Lettuce.—Our main crop was lettuce, for in previous experiments we had found a decidedly beneficial influence of the light upon it. This benefit was fully as apparent this year. There



Cross-Section of the electric light houses.

can no longer be any doubt as to the advantage of the electric light in the forcing of lettuce. The light was started October 19th, 1891. At that time, Boston Market lettuce four weeks old was set on bench 4, and seedling plants of Landreth Forcing were just showing on bench 3. The transplanted plants (bench 4) in the light compartment soon began to excel those in the dark compartment, and as early as October 27th, or a week after the starting of the light, they were perceptibly ahead of the others. In this time 40 hours of electric light had been expended upon the plants. The plants directly under the light, from seven to ten feet from the arc, were the first to improve. November 1st, the lighted plants were a fourth larger than the others, and they showed a marked tendency to turn towards the light. The plants, even to the farther extremity of the light compartment, gained steadily throughout the experiment, and they were ready for market from a week to ten days earlier than in the dark house. In quality and all other characters, this lettuce was indistinguishable from that grown under normal conditions.

The lettuce on bench 3—which had been sown there—behaved differently. For the first week or ten days, the plants under the light were stunted, notwithstanding the fact that they were farther from the lamp than those on bench 4, which did so well from the first. After some days of lingering, when the plants began to acquire three or four leaves, these seedlings began rapidly to recuperate and they finally overtook their companions in the dark house; but these plants never showed the superiority which the transplanted ones on bench 4 exhibited. We were prepared for this behavior, for we had observed it before, and Dehérain has reported similar results with other plants in his experiments in Paris. The reason for this injury to very young plants I shall not now attempt to discuss; it is sufficient for our present purpose to say that it appears to be better to sow lettuce under common conditions, and when the plants are well established, to transplant them under the light.

Lettuce was also transplanted into the upper bench, No. 1, in order to determine how far the influence of the light extends. The extremity of the light compartment was 40 feet distant from the lamp, and the roof is so low that much of the light was re-

flected, yet at this distance, where there was only diffused light, the plants at a month after the light started were much better than in the dark house.

The experiment was repeated with second and third crops of lettuce with similar results, and with several varieties. February 9th, Simpson lettuce was transplanted upon bench 4, and the customary increase under the light took place. March 22d,



The Electric Light for Lettuce Growing.

when the lettuce was nearly large enough for market, the light was transferred to house B, and thereafter the poorer plants received the light. These poorer plants soon showed the effect of the new conditions, and the time between the maturity of the two crops was considerably lessened.

Perhaps the best illustration which we found of the influence of the light upon lettuce was afforded by a crop upon bench 1, into which radishes were also planted. The interception of the light by the radish leaves had a most marked effect upon the lettuce plants which stood behind them, the adjacent plants which chanced to be exposed to the full light being much larger. The bench therefore presented a very uneven appearance when the radishes were removed, and the shadows from the radish leaves

could be traced in the lettuce. Similar results were observed where the dense shade of a rafter lay across the plants.

In this connection, I wish to call attention to the fact that W. W. Rawson, at Arlington, near Boston, now uses the electric light in the commercial forcing of lettuce. Some of his methods are described by the present writer in the August number of *American Gardening*, from which the accompanying illustration (p. 137) is borrowed. The house shown in the cut is 33x370 feet, covering nearly one-third of an acre. Along the north side of this house are three 2000-candle power lamps which are run all night. Mr. Rawson calculates that he receives a gain of five days in a crop of lettuce by the use of these lamps, and as he grows three crops during the winter the total gain is over two weeks of time. The gain from one crop is estimated to pay the cost of running the lights all winter. The effect of the light is said to be marked at the distance of 100 feet.

Endive.—Plants of endive were transplanted into bench 2 November 11th, at the age of five weeks. The plants in the two compartments were much alike throughout the experiment, and it is impossible to say if the light exercised any beneficial influence, but it is certain that there was no injurious influence. In the 1890 test, under the naked light, inside the house, endive was injured, but other plants, which are known to be benefited by a modified light, also suffered under those conditions.

Radishes.—Radishes of various kinds were grown upon benches 1, 3 and 4, between young lettuce plants. The first crop—which alone is considered here—was sown a week before the light started, so that the plants were well up when the test began. Harvest was made December 3d, and in the meantime 229½ hours of electric light had been expended upon the plants, or an average of 5.1 hours per night. The following table gives the results of the radish test :

RADISH TEST.

SAMPLES.		1.		2.		3.		4.	
		Average wt. of entire plant.		Av. wt. of tops of marketable tubers.		Av. weight of tubers marketable.		Per cent. of marketable tubers.	
		Light house.	Dark house.	Light house.	Dark house.	Light house.	Dark house.	Light house.	Dark house.
Bench 4.	French Forcing (<i>New Forcing Early French Deep Scarlet</i>)	Oz.	Oz.	Oz.	Oz.	Oz.	Oz.	Per ct.	Per ct.
	Non Plus Ultra	.229	.209	.158	.154	.138	.142	60.1	49.7
	Roman Carmine	.257	.232	.125	.114	.166	.179	78.2	66.6
		.236	.296	.162	.165	.177	.209	50.0	68.7
Bench 3.	Scarlet Globe	.173	.125	.125	.125	.125	.175	51.6	20.8
	Prussian Scarlet Globe	.352	.329	.193	.162	.216	.227	77.2	76.7
	White-tipped Gem	.327	.263	.150	.109	.200	.172	81.7	88.8
	White Box	.331	.328	.190	.221	.226	.206	55.7	58.0
Bench 1.	Deep Scarlet Turnip	.310	.184	.181	.067	.181	.053	66.6	70.0
	Blood-red Turnip	.299	.309	.167	.166	.176	.209	75.9	66.8
	White-tipped Scarlet Turnip	.360	.478	.253	.250	.210	.270	70.0	80.4
	Non Plus Ultra	.284	.180	.127	.075	.190	.155	84.6	69.4
	White-tipped Forcing	.240	.163	.112	.082	.146	.109	89.7	68.2
Average		.299	.258	.162	.141	.179	.175	70.1	65.3
Average for bench 4.		.241	.246	.148	.144	.160	.177	62.7	61.6
" " " 3.		.295	.261	.164	.154	.192	.195	66.5	61.1
" " " 1.		.298	.263	.148	.130	.181	.159	77.3	70.9

It will be seen from the averages in the first part of the table that the plants in the light house were ahead in every feature. It will also be noticed that the proportion of tops (column 2) to the entire plant (column 1) is greater in the light than in the dark house, the difference being that between 55 per cent. and 49 per cent. All these results are interesting when compared with our former experience, for they show how much the simple interposition of plain glass may modify the influence of the light. In 1890, under the naked light, radishes were uniformly injured, the loss ranging from 45 to 65 per cent. ; the same year under a light protected by an opal globe, the injury was still apparent, but the loss in tubers was only from one to five per cent. of the crop, but at the same time the weight of leaves was increased ; now this year, under light strained through a globe and a glass roof, there was an increase in both tubers and tops.

It may now be asked at what distance from the lamp the best

results were obtained, for our radishes this year were grown on three parallel benches covering a distance of 20 feet. Unfortunately, I cannot answer this question, for different varieties were grown on the different benches and the benches are therefore not comparable. The averages for the different benches are given in the second part of the table, however, but the figures are so contradictory that little can be learned from them. As a rule, the best results, as shown by the figures, were obtained on the bench farthest from the light, but this may be due to variety. More reliable figures can be obtained from different parts of a bed under the light, one sash being chosen from directly under the light and one from 13 to 15 feet away and where only diffused light reached the plants. These figures are as follows, all pertaining to the same variety, the Scarlet Globe :

Sample.	Average weight of entire plant.	Average weight of top.	Average weight of tuber.	Per cent. of marketable tubers.
Directly under lamp.....	70 gr.	30 gr.	40 gr.	71
13 to 15 feet from lamp.....	66 gr.	32 gr.	34 gr.	65

Decidedly better results were obtained from the sash directly under the light, for not only were the tubers more and larger, but the tops were less.

In no case, however, have radishes been sufficiently benefited to pay the cost of the light ; but our results seem to show that a well protected light is some assistance to them.

Beets.—Four days before the light started, October 15th, seeds of Early Egyptian beet were sown in both compartments, on bench 2. A month later, after 160 hours of light had been expended upon them, the beets in the light compartment were at least one-third larger than those in the dark house. Five months after sowing, the beets were removed, when it was found that 57 per cent. of the plants in the light house gave marketable tubers, against only 33 per cent. of those in the dark house ; and the total average weight of the plants in the light was about half an ounce greater than in the dark house. It must be said, however,

that the test with beets was hardly a fair one from the fact that the plants in the dark house received more bottom heat than the others ; but as the results corroborate those obtained from radishes, the figures may possess value.



Spinage grown in 1890. The low plant grew under normal conditions, the slender one under the naked electric light.

Spinage.—When the light was started, spinage was transplanted into bench 2 in both compartments. This spinage was Round Dutch, but it came from three different sources, in which the reader will be interested ; and I hope that I may be pardoned for a short digression to discuss a matter concerning the variation of plants. It will be remembered that in our earlier experiments under the naked light spinage ran directly to seed, while plants in the dark house made good edible leaves. This difference is shown admirably in the accompanying figures, which are taken from our Bulletin 30. The slender plant was grown under the light in 1890 and it ran at once to seed ; seeds from this identical plant were saved, and they were sown in plot No. 1 below. The low plant was grown in the dark house at the same time, and the seeds from it were sown in plot No. 2. Will the characters

which these plants assumed under our former experiment be perpetuated in the offspring? We shall see; and for comparison we shall use commercial seeds in plot No. 3.

Now, in the light-house, the best of these three plots was No. 2, the seeds which came from the low plant figured above; and the second best plot was No. 3, the commercial seed. In the dark house, however, the best plot was No. 1, or that coming from the poor plant shown above; the second best was plot No. 2. Thus it will be seen that commercial seed was always second or third; while No. 1 was once best and once third, and No. 2 was once best and once second. But it should be said that it was very difficult to distinguish between 1 and 2, while commercial seeds gave obviously poorer results. Two lessons are apparent from this test: 1. The characters of the parent plants were not hereditary; 2. Our own seed gave better results than commercial seed, and this was no doubt due to the fact that our seed, coming from single plants, had a less mixed or variable parentage than the other.

We shall now return to the influence of the light upon the spinage. A month after the light started, there having been an average of about 5 hours per night of electric light, all the spinage in the light house was from 10 to 15 per cent. larger than in the dark house and there was no greater disposition to run to seed; and this advantage was maintained, if not augmented, throughout the experiment. This result was unexpected, for in our first experiment spinage was very much injured by the light; but in that experiment the light was naked and was inside the house and the results are therefore not comparable with the present ones.

Cauliflower.—On January 8th, 1892, two dozen good cauliflower plants four inches high and bearing four or five leaves, were placed in 6-inch pots and divided between the two houses, on bench No. 2. The plants in the light house were ten feet from the lamp, and almost under it, so that they received the full glare of light. A month later, 93 hours of light having been expended, the plants in the dark house were noticeably stouter and more stocky than those in the light house, and two of the plants were forming heads, while those in the other house showed no sign of

heading. A week later, four good heads were growing in the dark house, one of them reaching a diameter of $3\frac{1}{2}$ inches, while none were visible in the light house. It was a week later that heads began to appear in the light house, or two weeks after they had been observed in the other plants; and at this time it was plain that the lighted plants were running to length, while the others were stocky. When the plants were cut, February 29th, the measurements were as follows:

SAMPLES.	Average total height of plant.	Av. length of stem below the leaves.	Average diam. of heads formed.	Average weight of heads.
Dark house.....	18.4 in.	6.2 in.	5.4 in.	5.3 oz.
Light house.....	19.5 "	7.7 "	4.2 "	5.2 "

These figures show that decidedly better results were obtained in the dark house; and it should also be said that more heads were obtained in that house. These results are unequivocal, but the plants under experiment were so few that general conclusions cannot be drawn. It is expected that this experiment will be repeated upon a much larger scale the coming winter.

Flowers.—Violets and daisies were grown upon bench 2. In both instances, strong plants were set in the beds a few days before the light started. The violets (Marie Louise) were all set in the light house near the partition—12 to 16 feet from the lamp—and they received the full benefit of the light. Half of the bed of 100 plants was covered each night with a black enamel-cloth box, provision being made for ventilation, and the other half received the light. Three weeks after the light started the exposed plants began to bloom, while no buds could be found in the darkened portion. It was not until five weeks after the starting of the light that a flower appeared in the darkened plants, while the others had continued to bloom. At this point the obscure violet blight appeared and the experiment with the light ceased.

Fifty strong plants of the low daisy (*Bellis perennis*) were divided between the two houses. Those in the light compartment were from 15 to 18 feet from the lamp, in rather weak light. The

first bloom appeared just four weeks after the starting of the light, and it was in the light house. For a month or six weeks thereafter the lighted plants bloomed more profusely ; but at that time the dark house plants began to surpass the others, both in numbers and size of flowers and vigor of plants. In other words, the lighted plants bloomed earlier and never made such stocky plants, and they soon exhausted themselves. It is possible that they would have endured longer if they had been established in the beds for a longer period before the light was put upon them.

When do the plants grow?—It is thought that plants grow mostly at night, using the materials which they have manufactured during the hours of sunlight. The question then arises when the lighted plants grew. Did they grow more rapidly than the others during their fewer hours of darkness, or did they grow when the electric light was burning? We have made many tests with auxanometers—instruments which measure and record the periodical growth of the plants. The most important fact which these readings have shown is that lettuce plants, under normal conditions, grow about as much in daylight as in darkness ; and the periodicity of growth was very irregular. Lettuce leaves were found to grow more rapidly in the light house for the first week or so, at which time growth became greater in the dark house. That is, the leaves matured more quickly under the light. The accompanying records show this. These are the records of the growth of a single leaf upon a well established plant in each house during four consecutive days, the leaf in each case being an inch and a half long when the test was begun. The measurements are here recorded in sixty-fourths of an inch, only the numerators being used : thus 4 means 4-64 inch. The four hours during which the light ran are shown by asterisks in the third column, and whatever gain the lighted plants made over the others is shown by asterisks in the following column ; it is therefore apparent at a glance what relation such increase bears to the hours of the artificial lighting.

GROWTH OF LETTUCE.

April 1.				April 3.			
Hour.	Dark house.	Light Asterisks show when light ran.	Gain. Asterisks show gain under light	Hour.	Dark house.	Light. Asterisks show when light ran.	Gain. Asterisks show gain under light.
11 A. M.	2½	4	*1½	11 A. M.		2	
12 M.	3	5½	*2½	12 M.		0	
1 P. M.	6	5	1	1 P. M.		½	
2	4	5½	*1½	2		2	
3	4	6	*2	3		6½	
4	3½	7	*3½	4		9	
5	3½	10	*6½	5		8	
6	3½	8	*4½	6		6	
7	4	*6½	*2½	7		*3½	
8	5	*7	*2	8		*4½	
9	6	*8½	*2½	9		*4½	
10	7½	*10	*2½	10		*3	
11	8	10	*2	11		4	
12	7	10½	*3½	12		4½	
1 A. M.	7½	10½	*3	1 A. M.		5	
2	7½	10	*2½	2		6	
3	8	10	*2	3		6½	
4	8	10½	*2½	4		6	
5	14	9	5	5		5	
6	5	9½	*4½	6		6	
7	8	12	*4	7		5½	
8	7	11½	*4½	8		1	
9	7	10	*3	9		2	
	139½	196½			26	101	
April 2.				April 4.			
12 M.	7	8	*1	5 P. M.	9	9½	*½
1 P. M.	4	10	*6	6	7	6½	½
2	10	12½	*2½	7	8½	*5	4½
3	9	10	*1	8	4½	*5	*½
4	8	10	*2	9	4	*3	1
5	5½	4	1½	10	3½	*2¾	¾
6	4	4	0	11	3½	4	*½
7	4½	*9	*4½	12	3½	4	*½
8	6	*11	*5	1 A. M.	4	3½	½
9	7	*11	*4	2	4	4	0
10	7½	*11	*3½	3	3½	4	*½
11	7	8½	*1½	4	3	5	*2
12	5	8	*3	5	4	4	0
1 A. M.	5	7	*2	6	3	3½	*½
2	6½	9	*2½	7	1½	2	*½
3	7	9	*2				
4	7	9	*2		67½	65¾	
5	7	9	*2				
6	6	10	*4				
7	5	11	*6				
8	1	8	*7				
9	0	1	*1				
	129	190					

The figures plainly show : 1. That the electric light did not determine the periodicity of growth. 2. That increase under the light occurred only during the first days. 3. That growth in both houses took place in daylight as well as in darkness. The conclusions suggested by this short record, I believe to be generally true of lettuce, when grown under the conditions here present.

SUMMARY.

1. The influence of the electric arc light upon greenhouse plants is greatly modified by the use of a clear glass globe or the interposition of a glass roof. Plants which are much injured by a naked light, may be benefited by a protected light.

2. As a rule, plants are earlier under the electric light than when grown in ordinary conditions.

3. The light can be suspended above the house with good effect.

4. Lettuce is greatly benefited by the electric light. An average of five hours of light per night hastened maturity from a week to ten days, at the distance of ten and twelve feet. Even at 40 feet, in only diffused light, the effect was marked. The light appeared to injure young newly transplanted plants.

5. Radishes were also benefited by the light, but not to a great extent. When the light was hung in the house, however, whether naked or protected by a globe, radishes were injured.

6. Beets and spinage appeared to be slightly benefited by the light.

7. Cauliflowers under the light tended to grow taller than in ordinary conditions, and to make fewer and smaller heads.

8. Violets and daisies bloomed earlier in the light house. This corroborates results obtained with other flowers in our earlier experiment.

9. The electric light does not appear to determine or modify the hours of growth of lettuce and some other plants which have been studied in this particular. Plants which are benefited, simply grow more rapidly during the customary periods.

10. I am convinced that the electric light can be used to advantage in the forcing of some plants.

L. H. BAILEY.

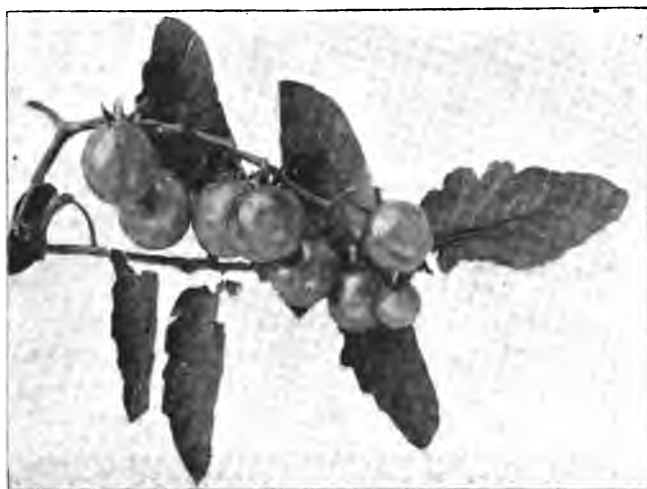
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SOME
Troubles of Winter Tomatoes



By L. H. BAILEY.

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BULLETINS OF 1892.

38. The Cultivated Native Plums and Cherries.
39. Creaming and Aerating Milk.
40. Removing Tassels from Corn.
41. On the Comparative Merits of Steam and Hot Water for Greenhouse Heating.
42. Second Report upon Electro-Horticulture.
43. Some Troubles of Winter Tomatoes.

SOME TROUBLES OF WINTER TOMATOES.

Nearly all forced plants are subject to many diseases and annoyances, arising from the fact that the enemies, as well as the hosts, are protected by the congenial and equable conditions of the glass house. As the cultivation of a given plant becomes more common and widespread, new enemies are likely to find it. The tomato is rapidly becoming an important winter crop, and its enemies are therefore coming into prominence. Two of these troubles—the winter blight and root-gall—are so obscure in their methods that growers often fail to recognize them until the crop is ruined; and as they already appear to be widespread in the north, it has been thought best to call attention to them.

1. *Winter blight*.—The most serious disease of forced tomatoes which I have yet encountered is what, for lack of a better name, I propose to call the winter blight, and which is the chief concern of this paper. This disease, so far as I know, has not been described except in a short communication from this Station in *Garden and Forest* last April.* It has not yet been carefully studied in the laboratory, but various attempts have been made to check it; and as it is likely to prove a serious disease, the attention of both growers and experimenters should be called to it. The object of the present report is to record the disease and to draw attention to it, rather than to present any full analysis of it. The disease first appeared in our houses in the winter of 1890–91, when about a dozen plants were somewhat affected. At this time the trouble was not regarded as specific; the plants were old and had borne one crop, and it was thought that they were simply worn out. In some of our experiments it became necessary to

*A New Disease of the Tomato, by E. G. Lodeman. *Garden and Forest*, v. 175.

carry about a dozen plants over the summer, and these were introduced into the house when the forcing season opened last October. From this stock, the trouble again spread and in six or eight weeks it had become serious and there was no longer any doubt that we were contending with a specific disease.

This blight attacks the leaves. The first indication of the trouble is a dwarfing and slight fading of the leaves, and the appearance of more or less ill-defined yellowish spots or splashes. These spots soon become dark or almost black, and the leaf curls and becomes stiff, the edges drawing downward and giving the plant a wilted appearance. This condition of the leaf is well shown in Fig 1. The spots grow larger, until they often become an eighth of an inch across, or even more, and they are finally more or less translucent. This injury to the foliage causes the plant to dwindle, and the stems become small and hard. Fruit produc-



FIG. 1. Leaf diseased with winter blight. Half size.

tion is lessened, or if the disease appears before flowers are formed, no fruit whatever may set. In two or three instances, in which young plants were attacked, the disease killed the plant outright, but a diseased plant ordinarily lives throughout the winter, a constant disappointment to its owner, but always inspiring the vain hope that greater age or better care may overcome the difficulty. Fig. 2 is a graphic illustration of the appearance of the disease. The box contains four plants, one of which is healthy, and three diseased. The small plant in the rear died before it reached full stature. It is not known that this disease attacks the fruit. Fruit-rot appeared on some of the plants, but it was apparently the same as that which attacks out-door plantations.

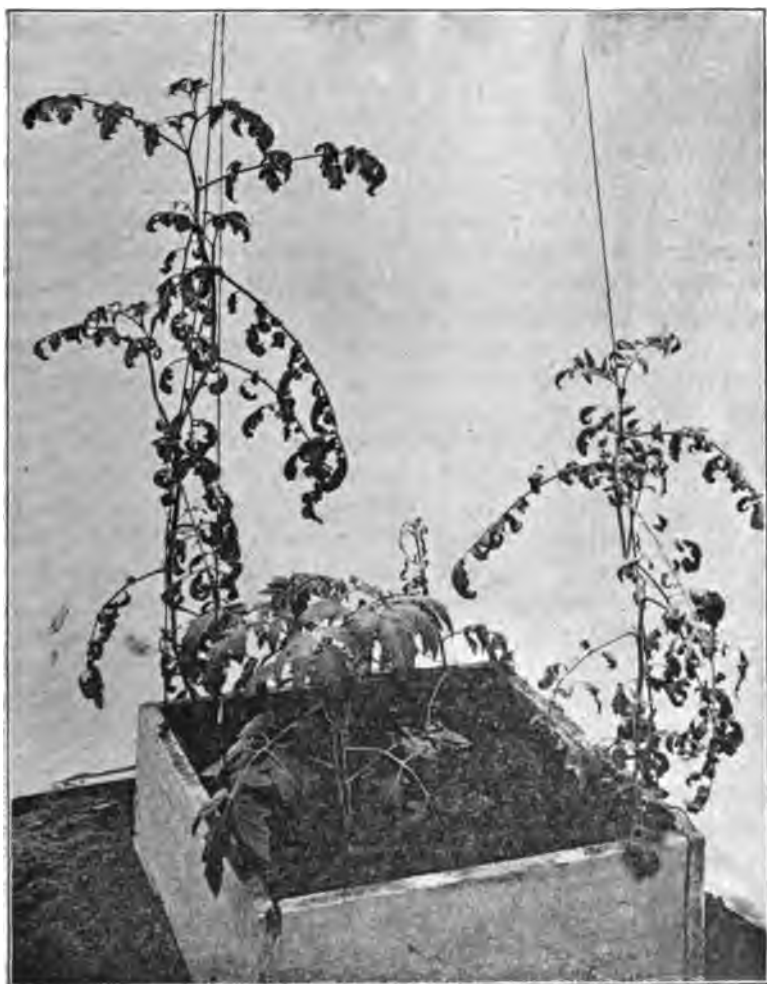


FIG. 2.—*The Winter Blight. A healthy plant in the front.*
(See pages 150 and 154.)

It soon appeared probable that the disease is bacterial in origin and it was at first thought that it is identical with the bacterial potato blight and that our plants had originally contracted the disease from soil taken from an infested potato field ; and this view was supported by the testimony of others who had been troubled with it and who had taken soil from potato plantations.* Specimens were submitted, however, to Dr. T. J. Burrill, of the University of Illinois, who replies that the trouble is probably not the same as the potato disease. A diseased tomato cion was grafted into a potato plant, and the stock for some inches below the union became diseased and finally died ; and this potato stock abounded in germs to all appearance like those infesting the cion, but inoculations from pure cultures were not made and it is not safe to say that the tomato disease can be transferred to the potato. Potatoes were planted in boxes containing diseased tomatoes and they did not contract the disease ; and a crop of potatoes was also grown on one of the benches in the tomato house, separated from the diseased tomatoes only by a three-foot walk, and it remained healthy. Tomato plants at this distance from affected plants invariably took the disease. It was then thought that the disease might be identical with the southern tomato blight described by Dr. B. D. Halsted in Bulletin 19 of the Mississippi Experiment Station. Specimens were sent him, when it was found that the two are distinct both in external appearance and in the character of the organism, the germ of the southern blight being a bacterium while this is a micrococcus.

All that is known further concerning the probable cause of the disease will appear in the following report from Professor W. R. Dudley, who has made some preliminary examinations of the diseased plants :

" I find a species of micrococcus present in limited numbers in the cells of the tomato leaves, both in those which were blanched, indicating the earlier stages of this disease, and in those blackened by its later development, and also in the diseased fruits. Moreover, the external aspect of this disease,—the blackening or

* In Horticulturists' Rule-Book, 2d ed. (p. 59), which was going through the press at this time, the statement is made that "the bacterial potato-blight or rot also attacks tomatoes." I do not know if this statement is true.

blighting of portions of the plants—is such as characterizes diseases occasioned by bacteria in other plants. Nevertheless, the preliminary cultures made did not give any results supporting this theory. Sterilized nutrient agar-agar* was infected with sap from the diseased tomato leaves and fruits with no result whatever; while similar infection from the stem of a potato infested with apparently a bacterial disease,† gave a cloudy-white growth along the track of the infecting wire and on the surface of the agar-agar which microscopical examination showed to be due to a minute micrococcus. Experiments necessary to the determination of this as a specific organism producing this particular tomato disease have not been made. Nor were other nutrient solutions used, which might have been more acceptable food for the micrococcus in a pure culture.

“I cannot feel sure that this disease was caused primarily by bacteria, which were certainly not present in great abundance. From microscopic examination of a considerable number of leaves from various sources, and observations in relation to this disease, on winter-grown tomatoes elsewhere, I think that no injurious effects of bacteria will appear, if houses are kept clean, properly heated and ventilated so that the vitality of the plants will not be impaired, and also if the houses are renovated at intervals.”

We are carrying diseased plants over the summer, and a critical study of the disease will probably be made the coming winter. We shall also be glad of any experience which others may have had with the trouble, and specimens of affected plants are desired.

Various treatments have been tried upon this disease. Our first attempt was thorough spraying with ammoniacal carbonate of copper, and this is the one which first suggests itself to growers. Our efforts, although carefully made at intervals, were wholly unsuccessful. It was then thought that treatment of the soil in which new plants were set might prove effective, and as

* Agar-agar is a gelatinous vegetable substance used for making cultures of bacteria.

† This potato stem had been grafted with a diseased tomato cion. See p. 152.

our crop was grown in boxes—as shown in Fig. 2—the experiment was easily tried.

Boxes in which diseased plants had grown were emptied and the insides were thoroughly washed with various substances, as follows: three with dilute solution of ammoniacal carbonate of copper; two with lime whitewash; one with Bordeaux mixture; two with lye. Fresh soil was placed in these boxes and healthy young plants were set in them. The boxes were then placed in the tomato house, near both healthy and diseased plants. For three or four weeks the plants appeared to be healthy, but after that time the disease attacked them all without respect to treatment. The same result followed thorough watering of the soil with ammoniacal carbonate of copper, nitrate of soda, and lye. Fig. 2 shows a box which was treated once with ammoniacal carbonate of copper applied to the soil. The plants were somewhat diseased when the treatment was given. The disease progressed without check. One plant died, and a healthy plant was set in its place. This plant—which is conspicuous in the foreground of the illustration—was remarkably strong and vigorous for a period of three weeks, when it contracted the disease. In the meantime another plant—shown in the background—died from the disease. Late in the winter the remaining plants were removed from the box, the soil was again treated with ammoniacal carbonate of copper and fresh seedlings were set in it; but these plants also contracted the disease. Just before this last treatment was given a 10-inch pot was filled from the soil in the box, and a seedling from the same lot as those placed in the box was planted in it. The pot was set in the tomato house. This plant showed the disease in less than three weeks. The question at once arises if the disease was not communicated through the air from infected plants, rather than through the soil. This I cannot answer, but it is certain that the disease travels from plant to plant which stand in separate boxes, and whose tops do not touch. Through what distances this transfer can take place I do not know. We observed it to have occurred through a distance of two or three feet, but a plant which stood fifteen feet from diseased plants, but separated from them by a glass partition in which two doors stood open, did not take the blight. It is still possible that we may

find a successful treatment for diseased soil, if all affected plants can first be removed from the house.

All our experiments, therefore, simply lead us to the conclusion that the best treatment for this winter blight is to remove all diseased plants at once, and if it becomes serious to remove all the plants and soil in the house and start anew. They emphasize the importance of starting with new plants and fresh soil every fall. And all our experience has shown that the disease is fatal to success in tomato forcing, for we lost our crop in an endeavor to treat it.

2. COMMON BLIGHT (*Cladosporium fulvum*).—The blight which is oftenest associated with the forcing of tomatoes appears as cinnamon-brown spots on the under surfaces of the leaves, as indicated by the dot-shaded portions of the leaflet in Fig. 3. For-



FIG. 3.—Common Blight (*Cladosporium fulvum*).

tunately, this fungus is rarely serious. For ourselves, we have had no experience with it, but I see it occasionally in tomato houses. It is apt to appear in late winter or early spring, often not until the winter crop is nearly harvested. In such cases, the burning of the old plants as soon as the last fruit is off will be the best treatment. If it appears earlier, however, spraying with ammoniacal carbonate of copper is to be recommended.

3. *Root-Gall*.—Nematode injuries of roots have received much study of late and the attention of growers has been called to them in bulletins and in the press. But there are still very few

horticulturists who are aware of the extent to which they infest our greenhouses. Many common plants, as geraniums, begonias and coleus, are subject to their attacks, and the diseased plant—or the soil in which it grew—is often dumped into the dirt-bin, where it propagates the trouble. In the southern states the nematodes are serious enemies to many plants in the field, even to trees, but in the north they confine their attention mostly to in-door plants. This indicates that severe frost is fatal to them, and suggests a remedy in the freezing of houses which are seriously attacked, when this can be done to advantage, as between the crops of winter tomatoes. Nematodes are very minute animals belonging to the true worms, and allied to the trichinæ. These nematodes are a serious menace to tomato growing under glass. They attack the roots, causing the formation of galls, as in Fig. 4. The injury to the root is often much greater than that shown in the illustration. Sometimes the whole root is swollen into one ragged shapeless mass, strongly reminding one of the club-root of cabbage. The trouble is likely to be worst in those plants which are carried over from the preceding winter. In general appearance, plants injured by root-galls are very like those attacked by the winter blight already described, save that the leaves do not show a spotted discoloration. The plants become weak, stop growing, the leaves curl and become yellow and dry, much as if the plant were suffering for water.

The treatment for this disease is to remove the plants and soil, thoroughly wash the benches or boxes with lye, and begin anew. But it would be a great saving of time and expense if the soil could be treated, between the crops, with some material which would destroy the nematodes. This was tried in a small way. Five boxes, each containing four diseased plants, were selected for treatment December 11th, 1891. The plants were removed, and the soil was treated as follows :

1. One-third pound of concentrated commercial lye dissolved in a pail of water.
2. Two pounds of salt in a pail of water.
3. One pound of quick-lime in a pail of water.
4. Four tablespoonfuls of bisulphide of carbon poured into holes which were quickly closed.

5. The box removed out-of-doors and allowed to freeze solid. These boxes are 18 inches square and contain 10 inches of soil. Clean young plants were set in them after the lapse of four or

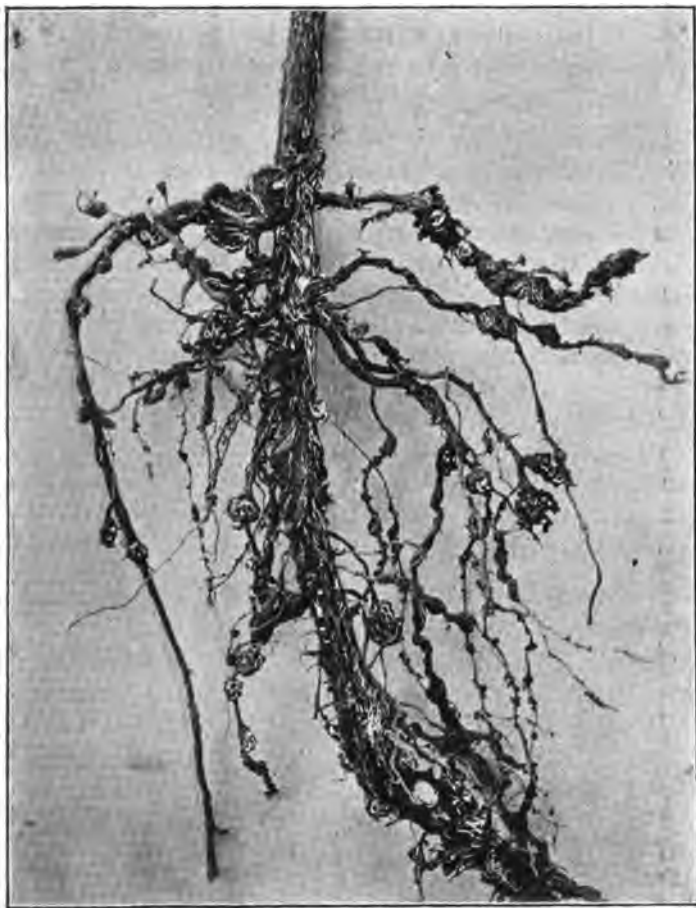


FIG. 4.—*Root-galls.*

five days, and the boxes were set side by side in the tomato house. One or two of the plants died in the soil treated with lye, and the places were refilled, while three settings had to be made in No. 2, because of the great amount of salt in the soil. Between each

setting the salt was washed out by heavy watering. When the plants were removed six months afterwards, it was found that all contained galls except those in boxes 2 and 5 — those salted and frozen—but upon these no galls whatever could be found. The results were definite and satisfactory, but the experiment was too limited to warrant any general conclusions. They inspire the hope that soils can be treated between the crops for nematodes.

REVIEW.

This bulletin calls attention to three diseases which attack forced tomatoes, at least two of which are serious. One is an obscure blight which appears to be caused by a bacterium, but for which no remedy is known. Removal of diseased plants, and thorough renovation of the house if the disease is serious, are recommended. One is the common blight or cladosporium, which is to be treated with a spray of ammoniacal carbonate of copper. The third is the nematode root-gall, the exact indications of which do not appear above ground. The prescribed treatment for this injury is the removal of plants and soil, and the washing of the beds or boxes with lye; but there are indications that freezing the soil or treating it heavily with salt may destroy the nematodes.

L. H. BAILEY.

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**Cornell University Agricultural Experiment Station
ENTOMOLOGICAL DIVISION.**

**THE
PEAR-TREE PSYLLA.**



By MARK V. SLINGERLAND.

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BULLETINS OF 1892.

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39. Creaming and Aerating Milk.
40. Removing Tassels from Corn.
41. On the Comparative Merits of Steam and Hot Water for Greenhouse Heating.
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THE PEAR-TREE PSYLLA.

Psylla pyricola.

Order HEMIPTERA ; family PSYLLIDAE.

The pear-tree has heretofore suffered less from the attacks of insects than other extensively grown fruits like the apple, plum, and others. Recently, however, a minute insect known as the Pear-tree Psylla, *Psylla pyricola*, has inflicted such severe losses upon pear growers that it threatens to seriously interfere with the successful cultivation of this fruit.

During 1891, pear growers, in restricted localities in quite widely separated portions of this and of neighboring states, lost thousands of dollars worth of fruit and many valuable trees through the ravages of this pest which suddenly appeared in enormous numbers early in the season. The pear orchard of Dr. Jabez Fisher, Fitchburg, Mass., was seriously injured ; and Coe Brothers, Meriden, Conn., had two orchards devastated by the pest. In New York State, orchards in the eastern, central and western portions suffered. On West Hill near Ithaca, Tompkins Co., several orchards were severely attacked, some of the trees ultimately dying ; Mr. H. S. Wright's orchard promised six hundred bushels of fruit, but less than fifty bushels matured, and but few trees made any growth. A severe attack prevailed at Menands, Albany County. Mr. G. T. Powell, an extensive fruit grower in Ghent, Columbia County, states that the insects reduced his pear crop from an estimated yield of twelve hundred barrels to an actual yield of less than one hundred barrels of marketable fruit ; the trees made but little growth and several were killed ; his trees have been noticeably losing vitality for two or three years due, no doubt, to the unsuspected attacks of this pest. These facts must convince the pear growers, of New York State especially, where the insect seems to have obtained the strongest foot-

hold, that they have to fear a very serious pest. Although very insignificant individually, this enemy becomes formidable and very destructive when the conditions are favorable for its reproduction in countless numbers.

THE PAST HISTORY OF THIS PEST.

The pest is an old offender ; and its recorded history in this country shows that it has been present for many years in or near most of the localities above noticed. The insect was probably first introduced into this country upon young pear-trees imported from Europe in 1832 by Dr. Ovid Plumb of Salisbury, Conn. Dr. Plumb first noticed the insect in 1833 ; and during the next five years he lost several hundred trees from its ravages. By 1848, when the pest was first brought to the notice of an entomologist, Dr. Harris, it had spread into Massachusetts and into Dutchess and Columbia Counties in New York. In 1879, W. S. Barnard observed the pest in destructive numbers at Ithaca and at Saratoga, N. Y.

The earliest record we have of its appearance further west is in 1871 when Dr. LeBaron recorded a severe attack upon young pear-trees in Illinois. Mr. E. A. Schwarz has found the insect in Michigan. Prof. J. B. Smith of New Jersey has been unable to find it in that State, and we have no record of its occurrence further south.

It is thus seen that the pest is quite widely distributed over the northeastern portion of the United States and has reached the Mississippi Valley in its westward progress. The severe outbreak of 1891 indicates that the insect has been increasing in numbers. It has apparently reached a point, in New York State, at least, where it only awaits favorable opportunities, in meteorological conditions possibly, to repeat its ravages of last year in unexpected localities. Pear growers should be watchful and prepared to fight it early in the season.

ITS CLASSIFICATION.

This pear pest is one of the true bugs belonging to the sub-order *Homoptera*, family *Psyllidae*, commonly known as Jumping Plant-lice from the leaping habit of the adult. Their general name, *Psylla*, is the Greek word meaning a flea. The *Psyllid*

fauna of Europe comprises more than one hundred and fifty described species and has been thoroughly studied. Dr. Franz Löw of Vienna added much to our knowledge of the classification of this group and he has described the life history and habits of several species.* Dr. E. Witslaczil of Vienna has written exhaustively on the anatomy of the family†.

In the United States but little attention has been paid to the *Psyllidae*, and less than twenty species have thus far been recognized.

Three species of *Psylla* infest the pear-tree in Europe,—*pyrisuga*, *pyricola*, and *pyri*; *pyrisuga* does the most damage, and *pyri* is comparatively rare. We have, as yet, no native species of *Psylla* feeding on the pear-tree. Our pest, *Psylla pyricola*, although it was observed in this country in 1833, received its name in Europe fifteen years later, or about the time Dr. Harris's attention was called to it here. Previous to 1848, European writers had referred to the species as *Psylla pyri*, not distinguishing it from that species; and nearly all of our entomologists have written of it under this name. *Psylla pyricola* sometimes attacks the apple-tree in Europe, but it seems to confine its attacks to the pear in this country.

INDICATIONS OF ITS PRESENCE.

Among the first indications that pear growers, who suffered from this pest in 1891, had of its presence was the noticeably lessened vitality of their trees early in the season. Old trees, especially, put forth but little new growth. Where new growth started, in many cases, the shoots began to droop and wither in May as if from a loss of sap. A little later, whole trees put on a sickly appearance; the leaves turned yellow and the fruit grew but little. By midsummer nearly all the leaves and half-formed fruit fell from many trees; this fact suggested the design on the title page of this Bulletin.

Another peculiar phase of the attack was the immense quantities of a sweet water-like fluid called honey-dew which covered the twigs, branches and trunks of the trees. In some instances

*In Verh. der K. K. Zool.—Bot. Ges. in Wien, 1862-1886.

†Zeit. für Wissensch. Zool. XLII, 569, (1885).

it appeared in such quantities that it literally rained from the trees upon the vegetation beneath ; in cultivating the orchard the back of the horse and the harness often became covered with the sticky substance dropping from the trees ; in gathering what little fruit matured the hands and clothing would become smeared with the sticky fluid. This honey-dew appears on the trees soon after the leaves expand and is found throughout the season. It attracts thousands of ants, bees, and wasps which feed upon it. If copious showers fall during the early part of the season much of this honey-dew is washed off, making it less noticeable.

At first the honey-dew is clear like water, but soon a black substance appears and, spreading rapidly all through it, gives it a disgusting blackish appearance as if the trees were covered with smoke from a factory. This black growth is a fungus, *Fumago salicina*,* which grows luxuriantly within the honey-dew, but does not attack the tree. It forms, however, with the honey-dew, a coating which must close many of the breathing pores of the tree and thus materially affect its healthy growth. Many trees appeared as though treated with a thin coat of black paint.

The attention of the Entomological Department of this Station was first called to the pest by Mr. H. S. Wright, Ithaca, N. Y., in the latter part of November, 1891 ; or not until the insect had done its damage for the season. A visit to his orchard a few days later revealed a most deplorable state of affairs. The whole orchard appeared as though a fire had swept quickly through it and scorched the trees, blackening the trunks, large branches and the smallest twigs ; both young and old trees of dwarf and standard varieties had been attacked, the Bartlett and Dutchess varieties suffering the most ; most of the trees had made little or no new growth during the season, and many buds were then dead. Neighboring orchards were similarly affected ; and Mr. G. T. Powell reported that his orchards at Ghent, N. Y., presented a similar appearance. Several trees in some orchards died before spring.

Although the indications of the presence of some enemy is

*W. S. Farlow, Bull. Bussey Inst., Mar. 1876, p. 404.

thus so conspicuous, the depredator is an insect so small as to be easily overlooked.

THE APPEARANCE OF THE INSECT.

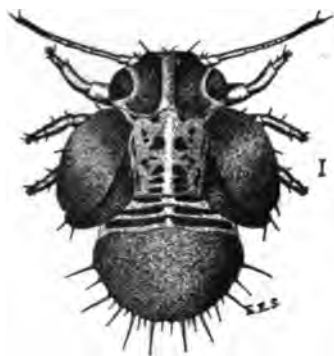


FIG. 1.—Full grown nymph, dorsal view.

inch in diameter; the natural size is indicated by the hair line at the right of the figures. These full grown nymphs are oval in shape, and of a general blackish color often tinged with red; the eyes are of a bright crimson color. A very conspicuous feature is the large black wing-pads on each side of the body. The whole body is very much flattened, being only one-fifth as thick as long.

The adult insect. Fig. 3:—From the full-grown nymph, the change is to the adult insect. In this form the pest strikingly resembles a Cicada or Dog-day Harvest-fly in miniature. It would take nine or ten of them placed end to end and about forty placed side by side to measure an inch; the hair line beside the figure indicates the natural size of an adult. From the wide blunt head, the body tapers considerably to the sexual organs at the

The immature insect. Figs. 1 and 2:—These curious minute, oval, immature forms are called nymphs. When first hatched they are of a translucent yellow color, and hardly visible to the unaided eye; eighty of them placed end to end would scarcely measure an inch. They increase in size quite rapidly and undergo gradual changes in color and form until they measure .055 of an inch in length and .045 of an



FIG. 2.—Full grown nymph, ventral view; a, anus; b, beak.

caudal end. When the insect is at rest, its two pairs of large, nearly transparent wings slope roof-like over the sides of the body. The general color is crimson with broad black bands across the abdomen. The legs have thickened femurs to aid the insect in leaping. The sexes are easily distinguished; in the male (Fig. 5) the abdomen terminates in a large trough-shaped segment from which project upward three narrow organs used in copulation; the end of the abdomen of a female (Fig. 6) resembles a bird's beak, an upper and a lower pointed plate coming together and enclosing the egg-sheath between them.

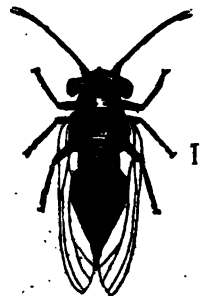


FIG. 3.—The adult insect.

THE LIFE HISTORY OF THE INSECT.

The life history and habits of every insect which becomes of economic importance should be accurately determined in order to ascertain, if possible, the stage when it can be most successfully combated. Observations upon the habits of the two worst enemies to fruit growers, the Plum Curculio, *Conotrachelus nenuphar* and the Codlin Moth, *Carpocapsa pomonella*, revealed peculiar habits which made it practicable to combat them with the cheapest and most easily applied of the insecticides,—the arsenites. The adult Plum Curculio's habit of feeding upon the fruit and foliage left it open to attack by the arsenical spray. The eggs of the Codlin Moth were found in the apex of the forming fruit soon after the blossoms had fallen; the fruit then being in an upright position the arsenite lodges in the apex and is eaten by the newly hatched larva when it attempts to enter the fruit. A knowledge of the habits of injurious insects will also often enable the farmer to so manage his land and crops that the insects are placed under very unfavorable and often destructive conditions. Wheat sown as late as it is safe to do so is usually secure from the attacks of the fall brood of the Hessian fly, *Cecidomyia destructor*. By harvesting the first crop of clover for hay early in June, the bulk of the first brood of the Clover-seed Midge, *Cecidomyia leguminicola*, will be destroyed and the second crop of seed be thus saved. Fall plowing destroys many cut-worms and the tender pupæ and

adults of wireworms which are hibernating. Many similar instances might be given where a knowledge of the habits of injurious insects have been of incalculable value to the fruit growers and farmers. In fact, were it not for such observations upon the life histories of insects, fruit growers and farmers would not now be so successfully fighting many of their insect foes.

Of the life history of the Pear Psylla but little has been recorded either in Europe or in this country, although the insect has been known here as a pest for nearly sixty years. As the attention of this Department of the Station was first called to this pest at the beginning of winter, our study of its life history naturally began with the stage in which the insect was then hibernating.

Hibernation.—Observers have differed in their statements in regard to the stage in which this insect passes the winter. Dr. Franz Löw, speaking of the three Pear Psyllids (Verh. der Zool. Bot. Ges. in Wien, 1886, p. 154) sums up the general European opinion on this point in saying that the adults hibernate and lay their eggs in the spring; not in the fall and spring as translated in Insect Life, IV, 127. Barnard, Thomas, and Ashmead (see bibliography for references) in this country have doubted that the adults of *Psylla pyricola* wait until spring to lay their eggs. Dr. Lintner (Country Gentleman, August 6th, 1891) says the winter is passed in the egg state. Some species of *Psylla*, as *P. mali*, appear to pass the winter in the egg state according to the observations of Schmidberger (Kollar's Treatise, p. 278) and English observers (Miss Ormerod's Fourteenth report, p. 4, 1891).

An examination of Mr. H. S. Wright's orchard in December, 1891, revealed a hibernating brood of adults. Notwithstanding the great numbers in which the insect had appeared during the summer, comparatively few of these adults could be found. Most of them were hidden in the crevices under the loosened bark on the trunk and large limbs of the tree; a favorite hiding place on some trees was in the cavity formed by the bark growing about the scar of a severed limb; on account of its being quite warm at the time, some adults were crawling about on the branches. The adults were not easily seen as they were so minute and their color so closely imitated the bark of the tree. Both sexes were found in about equal numbers, and an examination of the females in De-

cember showed no mature eggs. The trees were examined several times during the winter; the adults remained in their hiding places, and none were seen in copulation, nor were any eggs seen before April 7th, 1892. It was thus evident that *Psylla pyricola* does not pass the winter in the egg state, but that there is a hibernating brood of adults whose eggs are not laid until spring.

Oviposition of the winter brood.—A few days of warm spring weather occurred about April 7th, 1892, and many of the hibernating adults were seen in copulation, and a few eggs were also laid. Spring then opened and by April 18th a majority of the eggs had been deposited. The eggs were placed in the creases of the bark, or in old leaf scars, about the bases of the terminal



FIG. 4.—Egg.

buds of the preceding year's growth; some were seen about the side buds near the terminal ones. They were usually laid singly but rows of eight or ten were sometimes found. The eggs (Fig. 4) are scarcely visible to the unaided eye; it would take eighty of them placed end to end to measure an inch. They are elongate pyriform in shape, smooth and shining, and of a light orange yellow color when first laid, becoming darker before hatching. A short stalk on the larger end attaches the egg to the bark, and a long thread-like process projects from the smaller end.

The temperature conditions in the spring influence not only the time of oviposition of the winter brood, but also the duration of the egg stage. Eggs brought into the warm Insectary on April 7th hatched in eleven days. Other branches containing eggs were tied to trees near by, the end of the cut branch being kept in a vial of damp sand; these eggs hatched in seventeen days. The weather remaining cool, the eggs upon the trees under natural conditions did not hatch before May 10th, or more than a month after oviposition began. By May 18th, most of the eggs had hatched; and the hibernating adults had disappeared.

Habits of the nymph.—Immediately after emerging from the egg, the minute nymph seeks a suitable feeding place and is soon at work sucking the sap with its short beak which appears to arise from between the front legs. The favorite feeding places of the nymph, and to which their much flattened bodies are

well adapted, are in the axils of the leaf petioles and stems of the forming fruit. A few nymphs emerged in the spring before the leaves had expanded ; these nymphs crawled into the buds out of sight. When the axils of the fruit-stems and leaves become full, the nymphs gather in closely packed clusters about the base of the petioles and stems ; if very numerous they gather on the under side of the leaves along the mid-rib and often on the petioles of the leaf. The nymphs move about but very little, sometimes becoming covered with their own honey-dew ; if disturbed they crawl about quite rapidly. The only times when the nymphs seem to stop feeding is during the casting off of their old skin which has become too small, and which gives place to a new and elastic skin formed just beneath the old one. At the last moulting of the skin, which occurs about one month after the nymph's emergence from the egg, the adult insect appears.

Habits of the adult.—The adult insect has quite different habits from what it had when a nymph. The strong legs and wings of the adult enable it to spring up and fly away with surprising quickness upon the slightest unnatural jar or the near approach of the hand to its resting place. The hibernating forms, however, are quite sluggish in their movements and are readily captured when found. The summer forms fly readily from tree to tree and could easily be borne by winds for long distances, and thus infest neighboring orchards. The adults are provided with a beak with which they feed upon the tissues of the leaves and tender twigs of the tree. They seem to have no favorite feeding place.

Oviposition of summer broods.—Three or four days after their transformation from the nymph stage, the adults of the spring and summer broods copulate and egg-laying begins for another brood. These eggs are usually laid singly, sometimes several in a row or group, not on the twigs but on the under side of the tenderest leaves among the hairs near the midrib, or on the petiole near the leaf ; sometimes the female very adroitly places an egg or two in each notch of the toothed edge of the leaf. The eggs of the summer broods do not differ from those laid by the hibernating adult. The summer eggs, however, hatch in from eight to ten days under the warmer and more even temperature conditions.

Detailed account of a single generation.— A detailed study was made of the second generation of the pest to ascertain any peculiarities of any of its stages which might be of interest, or of aid in combating the insect. The breeding was done in the Insectary and field observations were made to verify the results as far as possible. The cages used consisted simply of a common lamp chimney set on the surface of the soil in a small flower pot; the top of the chimney was covered with Swiss muslin and a vial of water sunken into the soil kept the pear branch fresh for several days. These cheap and simple cages have been found very convenient and useful in breeding such small insects, or in getting the number of moults of larvæ isolated in them.

The females of the spring brood began to appear about June 10th, 1892, and many were laying eggs by the 20th. On the 21st, several females were placed in cages on uninfested pear leaves. Eggs were laid the following day. An egg is described and figured on page 168. When first laid they were tender and easily crushed; but in a few hours the shell became hard and the egg could be dislodged and quite roughly handled without injuring it. The shell was found to be impervious to several oils and weak alkalis. The acids and strong alkalis penetrated the shell and killed the embryo. The eggs hatched in from eight to ten days; a day or two before hatching the crimson eyes of the embryo could be plainly seen through the shell near the larger end of the egg.

The nymphs which emerged were oval in form and of a pale translucent yellow color with the abdomen more opaque and darker. The crimson eyes were large and distinct. The curious creatures were scarcely visible to the unaided eye, measuring only .013 of an inch in length. A slight constriction of the body marked the beginning of the abdomen which is fringed with eight or nine long and several short hairs. The wing-pads were not yet distinguishable. The antennæ had but three joints, two short basal and a long terminal joint tipped with two long bristles. The short stout legs terminated by minute claws enabled the nymphs to soon find a suitable feeding place. Several nymphs were immediately transferred to other cages, only one being placed in each cage. The next day the location of the

nymph was often readily determined by a globule of honey-dew several times larger than the little creature which had secreted it. After feeding thus for six or seven days the nymphs became too large for their skins which burst open along the middle of the head and back and the insect crawled forth clothed in a new and elastic skin that had formed beneath the old one. After thus moulting the nymph usually sought a new feeding place, leaving its old shriveled skin attached to the globule of honey-dew it had secreted.

In their second stage the nymphs increased about one-third in size, but were of the same general color except the tips of the antennæ which were black. There were four joints in the antennæ, a division of the third taking place at the moult. The segments of the abdomen were more distinct and the wing-pads were developing. The nymphs remained in this stage about four days, when the second moult occurred.

At the third stage the nymphs measured .027 of an inch in length. The wing-pads were larger and blackish; and the other black markings which distinguish the full-grown nymphs were faintly outlined. Six or seven joints were now distinguishable in the antennæ, the last three being black.

About three days later, the third moult occurred. The nymphs differed from those of the third stage in having eight antennal joints; the wing-pads were larger; the nymphs were .038 of an inch in length; and the eyes had become of a dark crimson hue. In some cases the nymphs in this stage were very distinctly marked, differing from the full-grown nymphs only in having fewer and larger black spots on the thorax. The duration of this stage was about four days.

At the fourth moult, the markings which had been faintly visible since the second moult now came out very distinct. This proved to be the last nymph stage. The general appearance of the full-grown nymph is described on page 165. The black markings are represented in figures 1 and 2.

After feeding five or six days, the nymphs moult for the last time; at this moult the adult insect crawls from the nymph's skin. European observers have recorded but four moults for the nymphs of several species of *Psyllidæ*. The observations at the

Insectary were made upon several individuals isolated in small cages which were under daily observation from the emergence of the nymph from the egg to the appearance of the adult insect.

In each stage the nymphs secreted globules of honey-dew several times larger than themselves; sometimes the globule completely enveloped a nymph. After each moult the nymphs usually sought a new feeding place, leaving the old skin attached to the drop of honey-dew. The old moulted skins, of the last moult especially, often retained their form almost perfectly. So life-like did some of them appear, with the legs and antennæ naturally placed, that it often required close examination with a lens to determine whether the object was a live nymph or only the cast-off garment of one.

The whole life cycle of the generation studied, from the laying of the egg to the appearance of the adult insect, was about one month. The adults upon emerging are of a delicate greenish color; the blackish markings soon appear, however, and in two or three days the green changes to the normal reddish brown color. Although the adults are so distinct sexually, there seems to be nothing about the full-grown nymphs which would indicate the sex of the adult soon to emerge from the nymph's skin.

The adults begin feeding at once after emerging but do not increase visibly in size. They appear to secrete no honey-dew but void considerable quantities of a whitish excrement. Adults of the summer broods lived for several days in cages in the Insectary; how long they live under natural conditions has not been ascertained, probably less than a month. The adults which hibernate, however, remain alive for at least six months.

About a week after the summer broods of adults emerge, copulation takes place and the deposition of eggs soon begins. The winter brood, as has been said, do not, however, copulate and oviposit until spring. Several of the adults were observed with a lens while in copulation. The operation was of particular in-



FIG. 5.—Abdomen and genital organs of the male, side view; a, anus; f, forceps; l, lower genital plate; p, penis; u, upper genital plate.

terest ; for a glance at figures 5 and 6 of the sexual characters and abdomen will show that the male organs (Fig. 5, *a, f, l, p, u.*) are so peculiarly situated as to seemingly render the grasping of the female organ (Fig. 6, *a, e, l, u.*) no easy matter. It was found, however, that the caudal segments of the abdomen of the male were very flexible and enabled the trough or lower male genital plate (Fig. 5, *l*) to be curved upward, thus bringing the forceps (Fig. 5, *f*) in a position to grasp the upper genital plate (Fig. 6, *u*) of the female ; this allowed the penis (Fig. 5, *p*) to enter between (at *e*, Fig. 6) the valves of the female organ, and the upper male genital plate (Fig. 5, *u*) to simply lie along the venter of the lower genital plate (Fig. 6, *l*) of the female. A further slight side twist of the abdomen brought the male beside



FIG. 6.—Abdomen and genital organs of the female, side view; *a*, anus; *e*, egg-sheath; *l*, lower genital plate; *u*, upper genital plate.

or in some cases upon the female ; the wings of both remained in a resting position. The hair lines beneath figures 5 and 6 represent the natural length of the abdomen including the genital organs. Copulation lasts for several minutes, and one male may copulate with more than one female.

The number of broods.—The pest may be said to be many brooded, the number varying with the conditions of the season. The weather at the opening of spring greatly influences the time of appearance of the hibernating brood, and the date of the laying and hatching of the eggs. An overlapping of the broods occurs, so that after June 1st all stages of the insect, eggs, nymphs, and adults may be seen on the trees at the same time. This is due to the facts that the eggs of any female are not all laid the same day, and thus do not hatch at the same time ; and the duration of the stages of the nymphs vary slightly, thus varying the time of the appearance of the adults.

Observations at the Insectary and in the field have shown that during the present year, 1892, there has been at least four broods of the pest. The hibernating adults oviposited in April, and adults of this spring brood appeared about June 15th. The adults of the summer broods were the most numerous on or about the

following dates, July 20th, August 20th, and Sept. 25th; or a brood appeared about once a month. All stages of the insect were found on the trees as late as Sept. 20th; evidently winter must overtake some of them before they reach the adult state. The adults emerging in September and later were found to be all of the hibernating form.

Peculiarities of the winter brood.—The hibernating adults found in December, 1891, were so different from the descriptions of *Psylla pyricola* that they were believed to belong to another species, perhaps new.* When the summer adults appeared, however, they were readily recognized as the old offender *Psylla pyricola*. The hibernating adults differ from the summer adults in size, being nearly one-third larger; in their much darker coloring, the crimson becoming a dark reddish brown; and especially in the coloration of the front wings. The summer forms or typical *pyricola*, have the veins, even in darker specimens, of a light yellowish brown color, and the whole front wing has a slight yellowish tinge. The veins of the wings of the hibernating adult are invariably of a dark brown or black color; the front wings are quite transparent with more or less blackish shades in the cells and a blackish shade in the basal cell along the whole suture of the clavus. The male genitalia differ slightly in size in the two forms. Figure 3, page 166 represents an adult of the summer form; and the wings shown in figure 8, are also from a summer adult.

The hibernating adults were studied at the Insectary in connection with the descriptions of *Psylla simulans* and Dr. Löw's remarks† upon the difference between the Pear Psyllids. This

*Well marked specimens were submitted to Dr. C. V. Riley, the recognized authority upon American Psyllids. In his reply he says: "Your Pear-tree *Psylla* is a species which I have never seen before and which is not in my collection. Its general appearance is not that of our native species of *Psylla*, and it has, no doubt, been introduced from Europe. It is unquestionably different from *P. pyricola* which I have from Ithaca, N. Y., Connecticut and Massachusetts. Owing to the difference in the genital apparatus of the male it cannot be identical with *P. pyrisuga* and *pyri*, but agrees perfectly with the description of *P. simulans*."

†Verh. Zool. Bot. Ges. in Wien, 1886, p. 154. A translation of most of Dr. Löw's article occurs in Insect Life iv, 127. Dr. Löw gives a tabular statement

study left but little doubt that *Psylla simulans* was described from specimens of the winter form of *Psylla pyricola*.

This difference between the summer and the winter adults is common among the *Psyllidæ*, and has before led to their being described as different species. It seems not to have been suspected that these insects were truly dimorphic or appeared in two distinct forms during the year. The general impression seems to have been that the adults appearing in the fall were at first the same as the summer form; and that as winter approached, these adults gradually assumed the characteristics of the hibernating form. However, frequent observations upon *Psylla pyricola* in the field during August and September, 1892, have shown that from eggs laid about August 20th by typical summer adults, there hatched nymphs which showed no variations from the typical summer nymphs and from these nymphs there emerged about September 25th the distinct hibernating form *simulans*. The hibernating forms feed until the leaves fall and then seek their hiding places in which to pass the winter. None have been seen to copulate in the fall. But very few summer forms were seen after September 20th. Thus in our Pear-tree Psylla we have a case of true dimorphism. The summer form is the typical *Psylla pyricola*, and may be designated when necessary to refer to this form alone as *Psylla pyricola pyricola*; while the hibernating form should be known as *Psylla pyricola simulans*.

Honey-dew and excrement.—Many have supposed that the honey-dew, so conspicuous a feature in severe attacks of this pest, is the sap of the tree which exudes through the punctures made by the insects. As the honey-dew occurs in such immense quantities it does seem almost impossible that it is wholly the secretion of the little creatures. All of this fluid

of the differences between *Pyrisuga pyri* and *pyricola*, and briefly points out how *simulans* differs from *pyri* and *pyricola*. A serious error occurs in the translation in connection with *simulans*. The sentence preceding the last in the translation should be divided into two, the period occurring after the phrase, "Along the whole fold of the clavus." The remainder of the sentence is not only incorrectly translated but it should form a distinct sentence. Dr. Löw says: "The tip of the clavus is larger with more black and in the hind basal cell there is a brownish or blackish stripe along the whole suture of the clavus. The forceps of the male are as in *Psylla pyricola* only a little wider."

does, however, first pass through the body of the insect. The amount which a single individual will secrete during its lifetime is small, but when many thousands of the insects occur on a tree, the aggregate becomes large. A single nymph isolated in a cage, secreted at least four drops (i. e. four minimis) of the fluid before it became an adult. Thus fifteen nymphs would secrete one drachm.

The food of the insect consists entirely of the sap of the tree. The feeding apparatus, both in the nymph (Fig. 2 *b*, p. 165) and the adult stage consists of a short, pointed beak which apparently rises from between the front legs. The sucking organs are three long thread-like setæ which move along grooves in the beak; in many cases, when the nymphs are quickly killed, the setæ are found extruded as shown in figure 2, page 165. In sucking, the point of the beak is placed against the tissue and the setæ are forced into the sap cells. The sap is then drawn up through the beak into the body. In the case of the nymphs most of the food is elaborated into honey-dew; some is assimilated, and the waste matter voided as excrement. The adults, however, seem to secrete no honey-dew, all the food being assimilated. Consequently the adults void considerable quantities of excrement, much more than do the nymphs.

The honey-dew and excrement are very different substances, but the fact does not seem to have been before observed. The honey-dew is a clear water-like liquid and forms into globules when secreted. The excrement, however, is a whitish semi-solid substance which is voided in long cylindrical strings, or minute whitish balls which roll from the anus like quicksilver globules.

In the adult, the anus is situated upon the dorsal surface. In the female it is just at the base of the upper genital plate (Fig. 6, *a*, page 173); in the male, the anus opens upon the tip of the upper plate (Fig. 5, *a*, page 172). In voiding the excrement, the male twists the abdomen downward so that none of the whitish substance adheres to the anus. The females, however, cannot thus twist the body and some of the excrement frequently adheres as whitish flakes; or not dropping freely, it sometimes forms into a string often reaching one-half an inch in length. In the nymphs the anus is situated on the venter near the caudal end (Fig. 2, *a*,

page 165) of the abdomen. It is surrounded by a ring of large wax-cells; a similar ring also surrounds the anus of the adult female. The excrement of the nymphs is usually voided in a string. It has often been seen in the midst of a globule of honey-dew secreted by the same nymph; thus clearly demonstrating that the two secretions are distinct.

Many observations were made to discover, if possible, the manner in which the honey-dew was secreted by the nymphs. It has been supposed that the secretion came, either from the long so called wax-hairs around the edge of the abdomen, or from excretory pores on the dorsum of the abdomen. Globules of honey-dew were, however, seen attached to the nymphs in such a position that it seemed very improbable that it came from either of the above sources; it seemed that it must have been secreted from the anus of the nymph. A German observer now asserts that the honey-dew secreted by the common plant-lice or Aphids comes from the anus, and not from the honey-tubes as commonly supposed.* Honey-dew thus seems to be what might rightly be called the fluid excrement of the insect.

METHODS OF PREVENTING THE RAVAGES OF THIS PEST.

All of the attempts to prevent the ravages of this pest during 1891 were ineffectual. This was due, in large part, to a lack of knowledge of the life history and habits of the pest. No severe outbreak had occurred within recent years which would call the attention of the fruit growers to the pest. The result was that when the insect appeared in enormous numbers early in the spring of 1891, fruit growers were at a loss what to do and how to do it; and entomologists could only suggest methods which seemed practicable. In most cases the attempts to combat the pest were begun too late; most of the damage had been done, the fruit and new growth being severely blighted; the nymphs had covered themselves with honey-dew, and the very active summer adults had appeared. After several unsuccessful attempts with various substances such as kerosene emulsion, solutions of whale-oil soap, fir-tree oil, and carbolic acid, and London Purple and

*M. Büsgen *Jenaische Zeitschrift* XXV. 339-428 (1891).

Paris Green, the afflicted fruit-growers gave up in despair. Nothing seemed to check the pest. They saw the leaves and most of the fruit fall before midsummer; and some of their trees were left in a dying condition, while others presented a blighted, blackish, desolate appearance. Fruit growers reported two causes which rendered their efforts ineffectual. These were peculiar phases in the habits of the insect. First, the nymphs were so completely enveloped in honey-dew that none of the insecticides reached them. Second, the activity of the summer adults rendered it impossible to reach them with a spray; as soon as the first spray struck a tree, the adults arose instantly and flew to some distance, remaining away till the spraying ceased.

During 1892, the pest has done no perceptible damage in orchards which it devastated last year. Fruit growers noticed that the pest considerably decreased in numbers later in the season last year. This decrease and the scarcity of the insect this year was probably due principally to the fact that the insect feeds almost exclusively upon the tenderest leaves and branches of the trees. As hardly any new growth was formed and as most of the leaves fell off early in the season, the insect was thus deprived of its favorite food and consequently its increase checked. So great was the decrease that but very few of the hibernating adults appeared. On this account we tried no experiments to destroy the adults in their winter hiding places. It seems practicable, however, that a thorough washing of the trunks and larger branches of the trees in winter with kerosene emulsion (at least five per cent. kerosene) or a strong soap solution, would destroy many of the adults.

As soon as the eggs of the hibernating form were found, experiments were begun with a view to the destruction of the insect in this stage. As the eggs were so freely exposed on the bare twigs to the action of any fluid, it was confidently expected that the pest could easily be checked here. Both field and laboratory experiments were conducted. The branches containing the eggs were dipped into the solution in each case, thus making sure that the treatment was thorough. The results obtained were very surprising. Eggs dipped in the following substances hatched a few days afterward :—

Kerosene Emulsion (Hubbard-Riley formula) used full strength ; and diluted with three parts of water heated to 130°F.

Kerosene undiluted.

Turpentine Emulsion diluted with three parts of water.

Turpentine undiluted.

Crude Carbolic Acid Emulsion diluted with ten parts of water.

Resin Wash used triple strength ; and heated to 130°F.

Whale-Oil Soap and Sulphide of Potash Wash used double strength. These last two washes are successfully used in combating all stages of scale insects.

Concentrated Potash, one pound to one gallon of water.

Benzine undiluted.*

Most of the above substances injured the buds ; Concentrated Potash and Carbolic Acid when used in less dilutions killed the buds. These results made it evident that it was impracticable to fight the pest with insecticides while in the egg state.

However, if the pear growers could wait until about April 15th, before pruning their trees, they could destroy many eggs. Most of the eggs are laid by that date near the tips of the last year's growth ; so it is only necessary to cut back these shoots, as many growers do, and burn them, to destroy large numbers of eggs.

After the unsuccessful efforts to destroy the eggs with insecticides, we could do nothing more until the nymphs appeared. Some of the nymphs appeared before the buds had opened much ; these nymphs immediately crawled into the buds out of the reach of the insecticides. It was feared that all the young and tender nymphs would thus get out of reach. But a majority of the eggs did not hatch this year until many of the leaves had expanded,

*Similar results were obtained by E. S. Goff of Wisconsin while experimenting upon the eggs of Aphids. He found the shell extremely resistant, scarcely yielding to the strongest acids and alkalies. (*Insect Life*, iv, p. 327).

There seems to be no other records of any careful experiments with the different insecticides upon the eggs of Aphids or of the allied Psyllids. Kerosene emulsion is often recommended, and the eggs of some species of Aphids may, possibly, be thus destroyed. There is need, however, of more observations upon the penetrating and killing power of insecticides upon the eggs, not only of Aphids but of other insects.

thus leaving the nymphs exposed. During a warm early spring the eggs might hatch early but many of the leaves expand in a few days and thus the nymphs would be exposed before they had become more than one-third grown.

Our experiments against the young nymphs were first carried on in the Insectary upon infested branches brought in from the field. It was soon found that the young nymphs were very tender and very susceptible to kerosene. A kerosene emulsion was prepared according to the Hubbard-Riley formula.* The nymphs were dipped in the emulsion diluted with different quantities of water. It was found that every nymph was killed by the emulsion even when diluted with twenty-five parts of water, and thus containing less than three per cent. of kerosene. The nymphs died almost immediately after the liquid touched them. These laboratory results were thus very encouraging.

Field experiments were soon begun to test the practicability of the emulsion. No trees could be found that were very badly infested. But by carefully examining the trees before and soon after spraying it was estimated that from 75 to 90 per cent. of the nymphs were killed by one spraying with kerosene emulsion

*The formula is $\frac{1}{2}$ pound hard or soft soap, 1 gallon water, 2 gallons kerosene.

First, thoroughly dissolve the soap in boiling water. While this solution is still very hot add the kerosene; if the whole is then left over the fire for a few moments to raise the temperature of the kerosene slightly, it will facilitate the emulsifying process. Remove from the fire and quickly begin to agitate the whole mass through a syringe or force pump of some kind; draw the liquid into the pump and force it back into the dish. Continue this operation for five minutes or until the whole mass assumes a creamy color and consistency which will adhere to the sides of the vessel, and not glide off like oil. If desired for use immediately, it may now be readily diluted with cold water, preferably with rain water. Or the whole mass may be allowed to cool when it has a semi-solid form, not unlike loppered milk. This stock if covered and placed in a cool dark place will keep for a long time. In making a dilution from this cold stock emulsion, it is necessary to measure out the amount of the emulsion required and first dissolve it in three or four parts of boiling water; if cold water be used a large quantity of a white flocculent mass rises to the surface and does not dissolve. After the stock emulsion is dissolved, cold water may be added in the required quantities. If all the utensils are clean, and the directions followed closely, no free oil will rise to the surface of the dilution.

diluted with twenty-five parts of water. Some of the nymphs had by this time become nearly full-grown, but these were as quickly and effectually destroyed as were the young ones. The habit of the nymphs of feeding in the leaf axils made it easier for the spray to reach them; the liquid would naturally run down the leaf petioles and twigs and gather in the axils, and thus become very effective. It was found that two quarts of the dilution was sufficient for a large dwarf tree; and thirteen such trees could easily be sprayed in half an hour with a knapsack sprayer. It would, of course, take more time and material to spray the large standard trees, but the whole cost for each tree would not be more than one cent a tree for time and material. The experiments with the kerosene emulsion against the nymphs were so successful that no other insecticides were tried. The emulsion is the cheapest effective insecticide now known for sucking insects; and our experiments have shown that it will prove a very practical and efficient means of checking the ravages of the Pear-tree Psylla if it be used thoroughly and in time.

The honey-dew did not interfere with the action of the insecticide this year, 1892. This was probably due to the fact that many hard showers fell during the early part of the season. The rain washed off much of the secretion. This fact should be taken advantage of by fruit growers in spraying for the pest. Spray soon after a heavy rain-storm if possible; a shower soon after spraying will not lessen the destructiveness of the emulsion as the nymphs are killed almost instantly. There is not the least danger of injury to the trees from the diluted emulsion. All dwarfs and young trees of all kinds may be sprayed with a knapsack sprayer.

The best time to spray is early in the spring just after the leaves have expanded. In 1892, about May 15th, was the best time. Then the first brood of nymphs had all emerged and were exposed in the axils. It was this first brood which did the most damage in 1891. Therefore it is very important that the insect should be checked early in the season. Fruit-growers should examine their orchards when the leaves are expanding in the spring, and if the nymphs are numerous no time should be lost in spraying the trees with the emulsion. A second or even a

third spraying could be profitably applied if the attack were serious, and especially if but little rain had fallen to wash off the honey-dew. The destruction of the nymphs is practicable during a period of two weeks about May 15th. If the spraying is thoroughly done at this time, the pest will be so completely checked as to necessitate but little, if any, further attention during the season. Most of the damage is usually done before June 15th, but spraying after this date will decrease the number from which the hibernating forms are produced; and thus the orchard may be saved from a severe attack the following year.

The summer adults were not numerous enough this year to thoroughly test the effect of spraying upon them. It seems from the experiments made last year by fruit-growers that it is hardly practicable to try to kill the adults by spraying. A few may be destroyed by coming in contact with the emulsion when they return to the tree.

TECHNICAL DESCRIPTIONS.

Full grown nymph.—Length, 1.4 mm.; width, 1.15 mm. Oval in outline, and much flattened, being only about one-fifth as thick as long. General color light yellowish brown often tinged with crimson, and distinctly marked with blackish. The distal end of the antennæ, of the beak, and of the tarsi are black. The large wing-pads, the whole dorsal aspect of the head except a light mesal stripe, and the caudal half of the abdomen both on the dorsum and venter are blackish or brownish black. The dorsum of the thorax and the cephalic half of the abdomen are marked on each side the light meson by sixteen blackish spots; the twenty-six on the thorax are of varying sizes and shapes; the six on the abdomen are narrow elongate. On the venter of the abdomen, eight and sometimes ten similar spots occur, two large oval ones on each side near the lateral edge, and two or three elongate ones farther cephalad on each side near the meson. The eyes are large and of a crimson color. The legs are slightly darker than the body. Oftentimes the light body color between the black markings is strongly suffused with crimson. Stout hairs or bristles project from the following situations: four from the front of the head; the basal and terminal joints of the antennæ each bear two; each leg has several; three project from the costal margin of each front wing-pad, and two from the outer margin of each hind wing-pad; and the caudal half of the abdomen is fringed with eight large and fourteen smaller bristles. The encircling row of wax-cells about the anus has a definite form which may be of specific importance.

Figures 1 and 2, page 165 drawn with a camera lucida, show the position of the anus with its encircling ring (Fig. 2, *a*); also the situation, relative size, and form of the bristles and blackish markings of the nymph.

Summer form of adult, Psylla pyricola pyricola, (Fig. 3, page 166): Length of body 2.25 mm.; the wings extend a little beyond the end of the abdomen. In general form they strikingly resemble a *Cicada* in miniature, the head is broad and held nearly vertical; the thorax is strongly built, and the pronotum, all four sclerites of the mesothorax, and the scutum and scutellum of the metathorax are distinct on the dorsum; the abdomen is cylindrical ovate, largest near the fourth segment and tapering to the genital organs. The general color varies from a light scarlet to crimson with black markings. Head (Fig. 7, a) broadly triangular, slightly concave caudad; the hair line just above the head in the figure represents the natural width including the eyes; the clypeus projects ventrad in the form of two separate diverging hairy cones (Fig. 7, c) with white tips and brownish red bases; the mesal suture of the epicranium is black with a lighter border, and a black spot occurs in a slight depression each side of the suture near the caudal border. The eyes are large and prominent, and of nearly the same color as the body except about the ventral aspect which is black; three minute ocelli are situated as shown in figure 7 at c. The antennæ are about one and one-half times as long as the width of the head and tipped with two large bristles; the first joint is reddish, the tenth, ninth, and distal half of the eight joints are black, and the remainder of the joints are light brown darker at their distal ends; the first and second joints are together equal in length to the fourth, the third is one and one-half times longer than the fourth, and the others are of nearly equal length; joints four, six, eight and nine are each furnished with a large sensoria near their distal ends. Figure 7, b, represents an antenna highly magnified to bring out the details of its structure; the hair line above the figure represents the natural length. The three-jointed beak is black, and passes through a deep groove just cephalad of the front coxæ. The pronotum is quite narrow; color, reddish black mesally with a whitish spot each side, and another similar slightly raised spot near the lateral edge within a slightly depressed elongate black spot. The præscutum of the mesothorax is large, convex, triangular in outline broadest caudad; color of cephalic half, except a narrow mesal stripe, black which merges into the crimson of the caudal portion; the lateral angles and a small tooth each side of the meson on the caudal border are whitish. The scutum of the mesothorax which bears the front pair of wings is large, convex and quadrangular in outline; color, a broad crimson mesal stripe wider at the ends with a blackish centre; each side of this a fusiform black stripe which is separated from a wider lateral black stripe by a narrow crimson stripe. The scutellum of the mesothorax

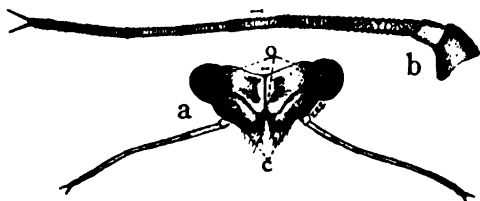


FIG. 7.—A, head of adult, front view; c, cones of clypeus; o, ocelli. B, antenna of adult greatly enlarged.

is broadest cephalad and slightly smaller than the præscutum; color, crimson with a whitish curved tooth projecting cephalad from the lateral angles. The postscutellum of the mesothorax is barely visible on the meson but is quite distinct each side the scutellum; color, brownish red. The scutum of the metathorax which bears the hind wings is narrow mesally but nearly as wide as the scutum of the mesothorax laterally; color crimson mesally merging into black at the sides. The scutellum of the metathorax is nearly round, slightly raised, and light crimson in color. Beneath, the thorax is marked with large irregular black spots. The legs are of a light yellowish brown color, except the thickened femurs which are black; all of the legs are thickly set with short hairs and the tibiæ and first tarsal joints of the hind legs are armed at their distal ends with densely black short spurs, five upon each tibia, three being set very close together on the under side, and two on each tarsal joint; the hind coxæ are the largest and have a long spur projecting caudad against the abdomen and which aids the insect in leaping. The relative size and shape, and the venation of the wings are shown in figure 8; the hair line beneath the front wing represents the natural size of the wing. The front

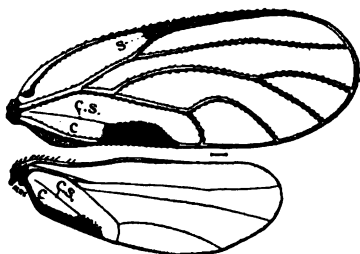


FIG. 8.—Venation of wings; *s*, stigma; *c*, clavus; *c. s.*, claval suture.

wings have a slight yellowish cast which partially obscures their transparency; in some specimens there are also yellowish shades in the cells. The hind wings are transparent and more delicate than the thicker, firmer front ones. The very strong veins of the front wings are always of a light yellowish brown color and are provided with short hairs on each side throughout their length; the stigma (Fig. 8, *s*) is usually but a little lighter in color than the veins; the tip of the clavus (Fig. 8, *c*) is brownish black in color, and a spot of about the same size and a little lighter in color occurs in the basal cell along the claval suture (Fig. 8, *c. s.*) opposite the blackish tip of the clavus. The veins and boundry of the basal third of the hind wings are yellowish and nearly as large as those in the front wings; the remainder of the veins are very indistinct; along the hind margin, the clavus is slightly thickened and is brownish in color especially at the tip and near the basal angle. The first abdominal segment is closely joined to the thorax and has a slightly raised nearly square black spot on the dorsum. The second segment, separated from the first by a distinct suture and slight constriction, has a small black mesal spot on the dorsum and a large irregular black spot on the sides. The following five segments each have a broad black band passing over the dorsum near the cephalic margin of the segments. Along each side on the lateral fold occurs a row of eight irregular black spots, seven of which contain each a spiracle. The second, third, fourth, fifth and sixth segments each have on the venter a broad black band similar to those on the dorsum. In the

female the eighth and tenth segments constitute the lower and upper plates respectively of the genital apparatus; these are black, and on the dorsum at the base of the upper plate is situated the brownish anus. The ninth segment constituting the sheath between the genital plates is brownish. Figure 6, page 173, shows the position of the anus (*a*); the appearance of the genital apparatus (*u*) upper genital plate; (*l*), lower genital plate; (*e*), egg-sheath; and the number, arrangement, and relative size of the black spots on the abdomen of the female as seen from the side; only that portion of the first segment which bears the spiracle is represented. The abdomen of the male (Fig. 5, page 172), differs from that of the female in being slightly smaller and longer; the eighth segment is distinct from the genital apparatus and has a broad black band on its venter in which the seventh spiracle occurs; the trough-shaped ninth segment is black and constitutes the lower plate (Fig. 5, *l*) of the genital apparatus; the upper plate (Fig. 5, *u*) or tenth segment is narrow and arises vertically at the base of the lower plate; this upper plate is blackish in color, lighter about the tips where the anus (Fig. 5, *a*) is situated; the forceps (Fig. 5, *f*) or claspers are a pair of narrow blunt black prongs arising from out the caudal end of the lower plate; these claspers curve slightly laterad before meeting at their tips and thus form an oval opening between them as seen from behind; the penis (Fig. 5, *p*) is also a paired organ arising as two narrow knobbed rods from near the middle of the trough. Figure 5, page 172, shows the arrangement of the markings on the abdomen, and the relative size and shape of the parts of the genital apparatus of the male when viewed from the side. Figure 3 represents an adult female of the summer form with the wings at rest.

Winter form of the adult, Psylla pyricola simulans.:—This form differs from the summer form only in size and coloration. It is nearly one third larger and the predominating color is black, due to the intensely black markings and the general dark reddish brown color of the body. On the head, the borders of the epicranium, about the base of the antennæ, and a spot near each eye are often whitish; about the base of the beak it is black and the cones of the clypeus are blackish with sometimes a whitish tip; the antennæ have their brown portions of a little darker color and the basal joint is often black. The tergum of the thorax varies from being only slightly darker in color than the typical summer form to nearly all black, there remaining only a narrow whitish caudal border on the praescutum of the mesothorax, the reddish mesal stripe on the scutum of the mesothorax appears as two narrow stripes so distinct is its black centre, and the curved whitish teeth of the scutellum of the mesothorax. The coxæ and tarsi are often blackish with the remainder of the legs of a darker brown. The front wings do not have the yellowish tinge and are thus more transparent; the veins are always of a dark brown or black color and more or less distinct black shades occur in the cells; in dark specimens these shades are very distinct; the stigma is slightly lighter than the veins; the tip of the clavus is distinctly black and a blackish spot occupying nearly one half of the basal cell extends along nearly the entire length of the claval suture; another blackish spot occurs on the clavus along the claval suture near its base.

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MARK VERNON SLINGERLAND.

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TOMATOES.



By L. H. BAILEY

AND

L. C. CORBETT.

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38. The Cultivated Native Plums and Cherries.
39. Creaming and Aerating Milk.
40. Removing Tassels from Corn.
41. On the Comparative Merits of Steam and Hot Water for Greenhouse Heating.
42. Second Report upon Electro-Horticulture.
43. Some Troubles of Winter Tomatoes.
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TOMATO NOTES FOR 1892.

1. *Quick and Slow Fertilizers.*—The influence of heavy manuring upon tomatoes has engaged our attention for a number of years. It is a common belief that the tomato, unlike most plants, is not benefited by rich soil or heavy fertilizing. "The plants run to vine," the gardeners say. There must be some truth in this belief, else it could not have become so widespread and be held so tenaciously. Productiveness in the tomato in the northern states is largely, if not chiefly, a question of early bearing: the plant will outlive any northern season, and its life is therefore determined by contingencies of frost rather than by any inherent limit of duration. The plant never matures here, and it would probably continue to bear for some months if not destroyed. We have carried plants in bearing condition through two winters. It is apparent, therefore, that any fertilizer which is not at once available to the plant but which gives up its materials comparatively late in the season, will maintain a vigorous growth and probably delay fruitfulness. Coarse stable manures belong to this class. It is some time before they become thoroughly decomposed and incorporated with the soil, and if applied heavily it is probable that they will give unsatisfactory results. If the season were long enough to allow the plant to live out its natural lifetime it is conceivable that the materials would be gradually used and that the total productiveness of the plant would be as great, if, in fact, not greater, than it would have been under a treatment which caused it to bear heavily at an earlier period. Thoroughly decomposed manures ought to give quicker and therefore more satisfactory results than coarse ones, and proper concentrated fertilizers might give better results than either. It would be interesting to know if stable manure applied in the fall,—and which therefore becomes thoroughly incorporated with the soil before spring,—

will give earlier fruitage than similar manure applied in the spring. We tried this experiment the past season, but the soil in the plots proved to be so heterogenous in character that we have no confidence in the results. We made a very suggestive test in this direction last year with nitrate of soda. Upon a certain area the material was applied all at once early in the season (June 25), and upon another equal area the same amount of nitrate of soda was applied in four applications from June 25 to August 28. Up to about the first of October, the yield from the first or single treatment area was 20 per cent. greater than from the other; but when the last picking (October 5) was added, the single treatment area fell some 8 per cent. behind. "This means," as the bulletin states, "that the intermittent application of fertilizer in lot two was beginning to be felt late in the season, while the single early application of the same amount of fertilizer gave quicker results. Frost held off until the second week in October, so that it happened that the intermittent fertilizing gave us the better result, but had frost come the last of September, as it frequently does at Ithaca, it would have given us the poorer result." This year the frost did come early (October 1), and the intermittent fertilizing gave us the poorer result. The figures which follow afford a most striking confirmation of the foregoing remarks, and they will bear careful study. Four plots, containing 15 plants each, were under experiment. In the first plot, 3 lbs. of nitrate of soda was applied at one time early in the season (June 20); in the second, the same amount was applied in four applications from June 20 to July 27; in the third, this amount was applied at four different times from June 20 to August 26, thereby extending the growing season very greatly; the fourth plot had no fertilizer. The plants were set in the field June 1, and they were all *Ignotum*. Table I gives the yields until frost (October 1). Table II gives the total yield found by adding to Table I all the fruits which remained on the plants after they had been killed by the first frost.

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TABLE I.—SINGLE VS. INTERMITTENT FERTILIZINGS, TO FROST.

Plots. 15 plants each.	Average num- ber of fruits per plant.	Average wt. of crop per plant. Lbs.	Average wt. of individual fruits. Ozs.
1. Single application. 3 lbs ni- trate of soda, June 20.....	24.2	10.0	6.6
2. Four applications. 12 oz. each, June 20, June 28, July 11, July 27	20.0	8.7	6.9
3. Four applications. 12 oz. each, June 20, July 21, August 8, Au- gust 26	15.2	6.6	6.9
4. Check	15.8	5.8	5.9

TABLE II.—SINGLE VS. INTERMITTENT FERTILIZINGS, TOTAL CROP.

Plots. 15 plants each.	Average num- ber of fruits per plant.	Average wt. of crop per plant. Lbs.	Average wt. of individual fruits. Ozs.
1. Single application of 3 lbs. ni- trate of soda, June 20.....	53.3	17.8	5.3
2. Four applications of 12 oz. ni- trate of soda, June 20, June 28, July 11, July 27	51.6	16.6	5.1
3. Four applications of 12 oz. of nitrate of soda, June 20, July 21, Aug. 8, Aug. 26.....	44.2	14.4	5.2
4. Check	31.1	9.8	5.3

The second column of figures gives the total yields. It will be noticed that the best yields, in each table, are given by the single fertilizing, and that between the intermittent fertilizings the one which was completed first (No. 2) gives the better result. This was true in both the yield before frost and in the total yield, but it must be observed that in the total yield the differences between the intermittent fertilizings and the single fertilizings are not so great as in the yield to frost ; that is, the intermittent fertilizings

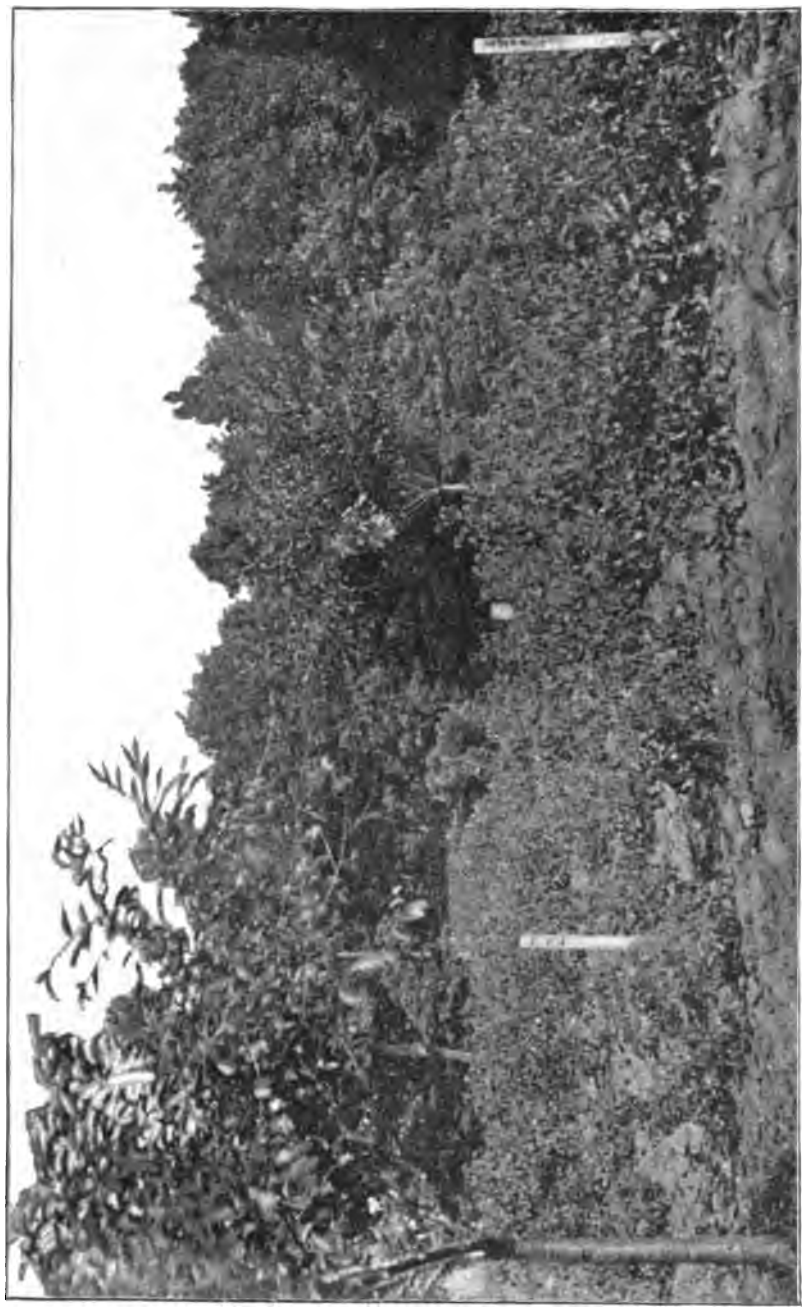
were catching up, and would probably have surpassed the other had the season been a month longer. Thus, in the first table, the first intermittent plot (No. 2) is 13 per cent. less in yield than the single treatment plot, but in the second table it is only 6.7 per cent. less; the second intermittent plot (No. 3) is 34 per cent. less in the first instance and only 19 per cent. less in the second instance. It will be noticed, also, that the number of fruits—in the first column of figures—follows the same course. All this is proof that productiveness in the tomato is largely a question of early bearing and that the best tomato fertilizers are those which give up their food materials quickly.

It must not be understood, however, that this early productiveness necessarily implies earlier individual fruits; that is, the idea refers rather to the production of many fruits—heavy pickings—early in the season rather than to the actual few first ripe fruits. A detailed account of the pickings from the plots illustrates this:

TABLE III.—SINGLE VS. INTERMITTENT FERTILIZING.
Detail Record

Date.	Plot 1. Single Fertilizing.		Plot 2. Intermittent Fertilizings. June 20-July 27		Plot 3. Intermittent Fertilizings. June 20-Aug. 26		Plot 4. Check.	
	No. fruits picked.	Wt. of picking	No. frts picked.	Wt. of picking	No. frts picked.	Wt. of picking	No. frts picked.	Wt. of picking.
July 27.....							1	...
Aug. 8.....	6	1 lb.	6	1 lb	4	1 lb.	12	4
Aug. 20.....							13	4.
Aug. 22.....	25	9	32	9	13	4	8	2.
Aug. 29.....	34	14	14	5	8	3	17	7
Sept. 2.....	42	17	29	12	11	6	30	11
Sept. 6.....	4	1	1	...	1	...	2	1
Sept. 8.....	77	31	60	27	52	23	50	19
Sept. 14.....	42	20	52	26	64	28	44	18
Sept. 21.....	32	14	36	18	27	12	22	9
Sept. 28.....	102	39	50	21	48	20	39	10

It appears that all the fertilizer plots were about equally early in first fruits, but after the first two pickings the single treatment plot gave the heaviest returns, and this advantage was main-



The Effect of Nitrate of Soda. The Nitrate was applied to the right-hand portion. Notice the bare spots in the no-treatment portion on the left.

tained throughout the picking season. As between the two intermittent treatment plots (Nos. 2 and 3), it will be observed that heavy pickings were much more early in No. 2, in which the fertilizing was completed late in July. The habit of the variety as to the season of its bearing was not greatly affected by the different treatments, but the amount of fruit borne at stated intervals was greatly influenced. It is probable that the plant had determined the date of its first fruiting, so to speak, before the fertilizer became available to it, for the plants were beginning to flower when the first application was made; but as soon as the fertilizer came into use, the habit of the plant was influenced, and the late fertilizing delayed, in a measure, the productiveness. At all events, I can offer no other explanation of the facts at the present time.

But these tests afford a means of comparing nitrate of soda with no fertilizing, for the check plot (No. 4) received no treatment. In each case, the check plot gives the poorest results, showing that nitrate of soda has a distinct value as a fertilizer. The differences in the appearance of the two plots (Nos. 1 and 4) is well shown in the accompanying engraving (page 193) in which the check plot occupies the left-hand portion. This appears like a contradiction of some of our former experiments in which we found no benefit to arise from the use of this material. But in former tests, the soil was very poor and there was very little potash or phosphorus to mate the nitrogen in the nitrate of soda; but in this test, the soil was fairly good. If we repeat our statements of a year ago, it will be seen that our present results are a confirmation of former trials rather than a contradiction of them: "It should be borne in mind that this substance [nitrate of soda] is an incomplete fertilizer and that unless the soil contains potash and phosphorus in sufficient amount the nitrate is nearly valueless. It is simply a convenient and useful form in which to apply nitrogen alone." So that, while nitrate of soda is a good tomato fertilizer when applied early upon fairly good soils, we cannot recommend that anyone should rely upon it exclusively year after year. Potash and phosphoric acid must also be applied at intervals.

2. *General Fertilizer Tests.*—We shall pursue this study of nitrate of soda still further in the following tests of the influences of nitrogen, potash, and phosphorus applied separately and in combination. Eight plots of six plants each, upon fairly good gravelly soil which had been sparingly enriched in previous years, were treated as follows June 20, the yield being given in the second column of figures :

TABLE IV.—FERTILIZER TEST, TO FROST.

Plots, 6 plants each.			Average no. of fruits per plant.	Average wt. of fruit per plant.	Average wt. of individual fruits.
				Lbs.	Ozs.
1	Nitrate of soda	1 lb...	30.0	9.5	5.07
2	Bone black	2 lbs...	19.6	5.8	4.8
3	Muriate of potash	1 lb...	24.2	7.7	5.1
4	{ Nitrate of soda	1 lb...	20.0	7.2	5.7
	{ Bone black	2 lbs...			
5	{ Nitrate of soda	1 lb...	27.5	7.1	4.4
	{ Muriate of potash	2 lbs...			
6	{ Bone black	2 lbs...	21.0	8.8	6.7
	{ Muriate of potash	1 lb...			
7	{ Nitrate of soda	1 lb...	19.8	7.3	5.9
	{ Bone black	2 lbs...			
8	{ Muriate of potash	1 lb...	23.4	8.9	6.1
	{ Check. ....	.....			

TABLE V.—FERTILIZER TEST, TOTAL CROP.

Plots, 6 plants each.			Average no. of fruits per plant.	Average wt. of crop per plant.	Average wt. of individual fruits.
				Lbs.	Ozs.
1	Nitrate of soda	1 lb...	50.6	14.5	4.5
2	Bone black	2 lbs...	25.4	7.2	4.5
3	Muriate of potash	1 lb...	34.6	9.6	4.4
4	{ Nitrate of soda	1 lb...	35.3	10.5	4.7
	{ Bone black	2 lbs...			
5	{ Nitrate of soda	1 lb...	36.0	8.0	3.6
	{ Muriate of potash	2 lbs...			
6	{ Bone black	2 lbs...	29.5	10.5	5.7
	{ Muriate potash	1 lb...			
7	{ Nitrate of soda	1 lb...	48.2	14.4	4.8
	{ Bone black	2 lbs...			
8	{ Muriate of potash	1 lb...	40.2	12.6	5.0
	{ Check.....	.....			

The first of these tables shows that nitrate of soda gave the heaviest yield before frost, and it was the only treatment which gave as good results as the check plot, which had no fertilizer. It is to be observed, also, that while bone black and muriate of potash gave the poorest results as single fertilizers, they gave the best result of any of the combinations. If we turn to table V., however, and study the total yield of the season, we notice that the nitrate of soda plot has perceptibly gained in proportional yield, and that the best combination is No. 7, which contains nitrate of soda; but the combination plot gives a trifle poorer results than the nitrate alone. These two instances are also the only ones which equal or exceed the yield of the no-treatment plot. These tests are a repetition of a series made in 1891, when one-fortieth acre plots were used. Last year, however, the trial was made upon very poor and intractable soil and nitrate of soda gave the smallest yields of the single treatments, and the best yield was obtained from a combination of all three materials, but even then the crop averaged to frost only 3.3 lbs. per plant, against 9.5 lbs. in the best yield this year, in a shorter season. The experiments of 1891 seem to show, therefore, that on very poor land nitrate of soda alone gives very little result, all the three elements being needed to produce even a small yield; the experiments of 1892 seem to show that upon tolerably good soil nitrate of soda alone may give profitable results, and this conclusion is strengthened by the other evidence which has been presented in this paper.

3. *Relation of Variety to Fertilizing.*—Last year we raised the question as to whether there is any difference between varieties in the readiness with which they respond to fertilizers. Are some types of varieties more likely to give good results from manuring than others? The small test made upon this point last season showed a decidedly greater tendency on the part of improved or highly developed varieties, like the Ignotum, to produce more fruits to the plant, but the total weight of crop did not appear to follow this course. This year, five varieties were submitted to this test, Ignotum representing the more improved types, Ithaca and Peach the intermediate types, and Yellow Plum and Red Cherry the least improved ones. On June 20, nearly three weeks after the plants were set in field, each plot, containing six

plants, received a liberal dressing of equal parts of nitrate of soda, muriate of potash, bone black and Bradley's vegetable fertilizer. The yields to frost are displayed in the following table:

TABLE VI.—RELATION OF VARIETY TO INFLUENCE OF FERTILIZER.

Variety. 6 plants.	Average no. fruits per plant.			Average weight of crop per plant.			Average weight of in- dividual fruits.		
	Unfer- til- ized.	Ferti- lized.	Per cent. in- crease.	Unferti- lized.	Fertil- ized.	Per cent. increase.	Unfer- til- ized.	Ferti- lized.	Per cent. decrease.
Ignotum	19.0	23.5	23.7	7.3	9.9	35.6	6.2	6.8	9.6gain
Ithaca.....	38.8	50.2	29.3	12.6	13.7	8.7	5.2	4.3	1.7
Peach.....	23.7	38.6	62.8	2.5	4.2	68.0	1.7	1.7	0.0
Yellow Plum	25.3	35.3	39.5	6.8	9.3	36.8	0.43	0.42	23.2
Red Cherry.	269.6	273.5	1.44	4.9	4.8	2.0 loss	0.29	0.28	3.4

These results agree with those of 1891 in the fact that the least improved variety—Red Cherry, in this instance—gave the least increase in number of fruits, but beyond this there appears to be no uniformity in the outcomes. It is remarkable that in the Red Cherry there was somewhat less total yield in the fertilized plot than in the other; yet the Yellow Plum, which is very little superior to it in degree of amelioration, gives a greater increase, both in number of fruits and in total weight of crop, than the Ignotum. Last year, the Ithaca gave the most remarkable response to the fertilizer, but this year it gave comparatively little response. It should be said, however, that the experiments of last year were made upon very poor soil, and the effect of the fertilizers was therefore undisguised; but this year the plots were upon good soil, somewhat variable in character, upon which the fertilizers produced comparatively small effect. We shall attempt to repeat this study upon a uniform poor soil.

4. *Early and Late Setting*.—Three lots of Ignotum, each containing twelve plants, were set in the field at different times, for the purpose of determining if the date of planting, within ordinary limits, greatly influences earliness and yield. The plants were all grown from seed sown January 19th, and they were

vigorous and stocky when set in field. The first lot, which may be designated No. 1, was set May 7. That night there was a frost and the tips of the plants were killed. Another lot was therefore set May 9. For some days the weather was cold and raw, although no frosts occurred, and for three weeks it was very wet. The third lot was set at the general planting, June 1.

TABLE VII.—EARLY AND LATE SETTING. Total Crop.

Plot.	Date of first picking.	Avg. no. of fr'ts per plant.	Average wt. of crop per plant.	Avg. wt. of individual fruits.
No. 1. Set in field May 7	Aug. 22.....	23.8	8.5	5.8
No. 2. " " " 9	July 27.....	26.7	9.5	5.7
No. 3. " " June 1	" 27.....	26.2	8.8	5.4

The results are decidedly in favor of the second planting, made May 9. Even the frosted lot nearly equalled the main planting, but the plants were so checked that the first ripe fruits were three weeks later than in the other lots. It will be noticed, however, that lot 2 was no earlier, so far as first fruits are concerned, than the late planting, but the first pickings were heavier in lot 2. In both lots, the flower buds had already appeared when the plants were set, so that the first fruits were already determined; in the earliest lot, these buds had been killed by frost. The following is a detailed account of the behavior of the plants to frost:

TABLE VIII.—EARLY AND LATE SETTING. Detail Record.

Date.	1. Set May 7.		2. Set May 9.		3. Set June 1.	
	Whole no. fr'ts picked.	Weight of picking.	Whole no. fr'ts picked.	Weight of picking.	Whole no. fr'ts picked.	Weight of picking.
July 27.....	.....	.....	1	.....	7	1
Aug. 8.....	.....	.....	.....	.....	3	1
Aug. 22.....	13	3	11	6	7	1
Aug. 29.....	26	8	23	7	26	7
Sept. 2.....	71	21	54	19	45	17
Sept. 8.....	43	20	50	20	61	25
Sept. 14.....	47	18	48	19	37	14
Sept. 21.....	34	13	45	15	53	13
Sept. 28.....	52	17	89	26	75	22
	286	100 lbs.	321	112 lbs.	314	101 lbs.

It will be noticed that the lessened productiveness of lot 1—the earliest setting—as compared with the main setting in lot 3, was due to the delay of fruiting caused by the injuries of the frost, for the pickings, when they once began, averaged heavier than in the latest setting. The great advantage maintained by the second setting—lot 2—was not due to absolute earliness, but to early productiveness; and this supports the conclusions which we have already drawn from our studies of fertilizers, that productiveness in the tomato is chiefly a question of early prolific bearing. These remarks may also throw some discredit upon the common method of determining comparative earliness of varieties by recording the date of the first ripe fruit: profitable earliness is determined by the ability of the variety to maintain heavy early pickings rather than by the date at which the few first fruits ripen.

This is the third year that we have made this test upon early and late settings, and our results have been substantially alike throughout,—that tomato plants are not injured by the cold raw weather of late spring, and that a slight frost may not greatly retard them. This conviction has been an unwilling one on the part of the writer, for he entertained the belief that the inclement weather of early May in the northern states is very prejudicial to the tomato. In our tomato bulletin for 1889 this statement was made: "It is a common mistake to set tomato plants in the field too early. Cold nights, even though several degrees above frost, check the plants, sometimes seriously." This statement now seems to be much too strong, and we are gradually adapting our general practice to our new belief. In 1889, our tomatoes were set in field June 10 to 12; in 1890, they were set June 12; in 1891, June 10; in 1892, June 1; and next year we shall set our plants in May.

5. *Early and Late Seed Sowing.*—In 1889 we made some tests to determine if it pays to start tomato plants under glass with artificial heat, rather than to wait until they can be started under cold frames. Sowings were made March 21 and 22, April 10, 12 and 15, and May 15. "In every instance the early sown plants gave earlier fruits than the others." "The gain in earliness sometimes amounts to three or even four weeks." We were

satisfied that in this climate it pays to start tomatoes as early as the middle of March. Farther south, where the seasons are longer, this may not be true. The question now arises if it pays to start tomatoes earlier than March, for this state. Four lots of Ignotums, twelve plants in each, were grown for a test. The first lot was sown January 19, and the plants were transplanted February 1, March 3, and May 17. The second lot was sown February 12 and transplanted March 4, April 4 and May 2. The third lot was sown February 24 and transplanted March 22 and May 2. The fourth lot was sown March 14, and transplanted April 14 and May 9. The plants were all set in field June 1, and all were thrifty and stocky plants. The outcome to frost was as follows :

TABLE IX.—EARLY AND LATE SEED SOWING.

Date of sowing.	Av. no. fruits per plant.	Av. wt. of crop per plant.	Av. wt. of individual fruits.
Jan. 19.....	20.6	8.5	6.5
Feb. 12.....	20.6	8.4	6.5
Feb. 24.....	21.0	9.1	7.0
March 14.....	26.0	11.0	7.4

The result, as read in the second column of figures, is decidedly in favor of the latest sowing, the second best yield being in the second last sowing. The earliest two sowings give practically the same results. The detailed behavior of the plants during the bearing season is recorded below :

TABLE X.—EARLY AND LATE SEED SOWING—DETAIL RECORD.

Date.	1. Sown Jan. 19.		2. Sown Feb. 12.		3. Sown Feb. 24.		4. Sown March 14.	
	Whole no. frts picked	Weight of pick- ing	Whole no. frts picked	Weight of pick- ing.	Whole no. frts picked	Weight of pick- ing.	Whole no. frts picked	Weight of pick- ing.
July 27.....	8	2 lbs.	3	1 lb.	...	...	...	...
Aug 8.....	...	...	7	2	9	3	4	1
Aug. 22.....	5	1	12	3	9	3	5	2
Aug. 29.....	11	4	12	4	25	10	8	2
Sept. 2.....	26	12	37	17	61	26	31	13
Sept. 8.....	37	19	37	16	51	23	49	25
Sept. 14.....	46	20	32	14	41	17	62	32
Sept. 21.....	38	14	36	14	18	6	26	11
Sept. 28.....	77	28	72	26	37	19	100	32

The figures show that the earliest fruits were got from the earliest sowings, but at the end of August the third sowing (February 24) had exceeded the earlier ones in yield. It was not until the middle and late September pickings that the fourth lot began to gain over the others, and by the last of the month it had surpassed them all in yield. Our experiments of four years ago show that it is profitable to start tomato seeds in this climate as early as the middle of March; our experiments this year show that it is not profitable to start them earlier than the middle or first of March. But inasmuch as earlier fruits can be got by earlier sowings, it may be worth while to start a small part of the crop in the middle or first of February if an early market is to be supplied; but the cost of this extra care and handling must be reckoned. The main crop, it appears, should be started in March.

But it must be said that much depends upon the manner in which the plants are handled. Early plants must be transplanted to keep them growing, and they must have congenial surroundings. We tried to determine the effect of ill treatment. A lot of vigorous seedlings, in pots, were placed in a cold and leaky house. The pots were packed in moss and set upon a cold, damp earth floor. Several times the mercury fell nearly to the freezing point.

The plants became yellow and weak, and were finally unable to support themselves readily. In this condition the plants were taken into the tomato house and given the most careful nursing. They never outgrew the disaster. Yet plants little better than these are often set in the field to shift for themselves!

6. *Few and Several Transplantings.*—The vigor and stockiness of plants, as we have said in the last paragraph, are important features, and these are greatly influenced by the frequency of transplanting. Two dozen uniform Ignotum plants were selected from a sowing made in flats March 14. One dozen were transplanted once, May 18th, into 4-inch pots; the others were transplanted three times, April 14, May 9 and 17, into a flat, 3-inch and 4-inch pots respectively. All were again transplanted into the field June 1.

TABLE XI.—FEW AND SEVERAL TRANSPLANTINGS, TO FROST.

Plot.	Date of first picking.	Average no. of fruits per plant.	Average wt. of crop per plant.	Average wt. of individual fruits.
No. 1, transplanted once.	Aug. 22	17.3	Lbs. 8.5	Ozs. 7.8
No. 2, transplanted three times.....	Aug. 3	22.2	8.3	5.9

There was very little difference in the yields of the two lots, but the three transplantings gave the earlier fruits, and in this respect the results agree with those obtained last year. In 1891, in a comparison of one, two and three transplantings, all lots being duplicated, the two transplantings gave decidedly the heaviest yields.

7. *Flat-grown vs. Pot-grown Plants.*—It is a question whether young tomato plants thrive better in "flats,"—or shallow tray-like boxes in common use among gardeners—or in pots. From each of two sowings of Ignotum, made February 12 and March 14 in flats, two dozen uniform plants were selected. One dozen, in each instance, were transplanted into flats, and one dozen into pots, on the same days. The transplantings were made as follows:

Series I (sown Feb. 12), March 4, April 4, May 3.

Series II (sown March 14), April 4, May 9.

The flat-grown plants in each instance were set so far apart in the flats that the plants could not interfere with each other, and at the final transplanting they stood from three to four inches apart each way. The pot-grown plants in the first series were transplanted into thumb pots and then into 3-inch and 4-inch pots. In the second series, they were placed in 3-inch and 4-inch pots. The records are these :

TABLE XII.—FLAT-GROWN VS. POT-GROWN PLANTS.

Samples.	Average no. fruits per plant.		Average wt. of crop per plant.		Average wt. of individual fruits.	
	Flat.	Pot.	Flat.	Pot.	Flat.	Pot.
<i>Series I.</i>						
March 14	30.4	26.0	11.2	11.6	5.7	7.0
<i>Series II.</i>						
February 12.....	20.5	31.0	8.6	11.5	6.7	5.9

The yields, in the second double column of figures, are decidedly in favor of pot-grown plants, especially in the later sowing. And it may also be said, although the table does not show it, that the pot-grown plants gave earlier fruits.

8. *Seedlings vs. Cuttings.*—In 1890, seedling tomato plants gave twice as heavy yields as cuttings of equal age. In 1891, seedlings gave earlier fruits, and with one variety—Lorillard—the yield was also much greater from seedlings, while in the Ithaca it was less. Secondary cuttings, that is, cuttings taken from the cutting plants, gave much larger yields than their parents, but the crop was much later. These experiments were repeated this year. The stock from which all the lots of this year came was one fine seedling plant of unknown parentage, of the Peach type, which came up in our forcing-houses. Late in winter, strong cuttings were taken from the axillary shoots of this plant and were set out regularly in our tomato house. In March, therefore, we had the one old or parent plant, still in full vigor, which we shall call A, and a small brood of cutting plants which we shall call, collectively, B.

March 29, 12 cuttings were taken from A. These cuttings were three to four inches long, and comprised the entire length of vigorous axillary shoots. At the same time, seeds were sown from fruits on the same plant. The two lots were thereafter treated as nearly alike as possible. They were set side by side in the field, June 1. Their behavior was as follows :

TABLE XIII.—SEEDLINGS vs. CUTTINGS (To Frost.)

Samples (March 29.)	First Pick- ing.	Av. no. frts. per plant.	Av. weight frt. per plant.	Av. weight in- dividual frts.
Seedlings.....	Aug. 22.....	23.6	3.9 lbs	2.0 oz.
Cuttings.....	Aug. 3.....	43.	4.8 lbs.	1.8 oz.

Here, then, the cuttings were both much earlier and more productive than the seedlings. This is opposed to most of our earlier results.

May 3, another batch of cuttings was taken from the old plant A. These were three or four inches long and were made from the tips of axillary shoots which had reached a foot or more in length. Seedlings were started from the same plant at the same time, and the two lots were placed side by side in the field. The results are like those above, only less pronounced :

TABLE XIV.—SEEDLINGS vs. CUTTINGS (To Frost.)

Samples, May 3.)	First pick- ing.	Av. no. frts. per plant.	Av. weight frt. per plant.	Av. weight in- dividual frts.
Seedlings	Sept. 2.....	12	2.1 lbs.	2.9 oz
Cuttings	Aug. 22.....	15.3	2.3 lbs.	2.3 oz

Now, at the same time that this last lot was started, May 3, a dozen good cuttings were taken from the plants B, which were themselves cuttings. These cuttings of cuttings were given the same treatment as the cuttings specified in the above table, and were set alongside them in the field. They gave their first picking August 22, the same date as the one-generation cuttings, but

they gave over twice the yield of either cuttings or seedlings—5.4 lbs. per plant, which is a fair yield for plants started in May. This, in general, tallies with our experience last year. We cannot account for it. Another strange thing about these cuttings of cuttings is the fact that they did not reproduce the parent type, A, but of this we do not feel competent to speak more fully at present.

9. *Products of Early and Late Fruits.*—A house plant of the Currant-Ithaca hybrid described last year (Bulletin 32, p. 165) gave its first ripe fruit December 3, 1891. Seeds were saved from this, and also from another fruit upon the same plant which matured March 18, 1892. These seeds were sown at the same time and at this time, also, cuttings were taken from the plant. The three lots made the following record :

TABLE XV.—PRODUCTS OF EARLY AND LATE FRUITS. (To Frost.)

Samples.	Date of first picking.	Av. no. of frts. per plant.	Av. wt. of frts. per plant.	Av. wt. of ind. fruits.
1. First ripe fruit.....	July 27.....	76.4	Lbs. 1.1	Oss. 0.22
2. Late ripe fruit.....	July 27.....	117.8	2.1	0.29
3. Cuttings.....	June 20.....	120.3	1.8	0.25

The poorest results were got from the seeds of the earliest fruit. The earliest picking was obtained from the cuttings, but the heaviest yield came from seedlings of the late fruit. The light yields are due to the variety, it being a cherry-like tomato. The table also affords a comparison of seedlings and cuttings, as



Products of Early and Late Fruits and Cuttings, at the first general picking. The left-hand and right-hand samples show products of late and early fruits respectively; the middle lot is from cuttings.

discussed in § 8, the cuttings being earliest, and producing more than one lot of seedlings and less than another. The accompanying picture shows the status of these three lots at the picking of July 27. The left-hand sample comprises all the fruits picked from the dozen plants of No. 2—products of late fruit; the middle one those picked from No. 3—the cuttings, and the right-hand sample is the picking of No. 1—the product of first ripe fruit. It may seem strange that early fruits should give less yield than late ones, but the result is not novel. We found the same thing to be true last year in a number of varieties, and similar results have been obtained elsewhere. In our experiments last year there were no constant differences between the sets in point of earliness. This illustrates the law that any fruit reproduces its parent rather than itself: that is, the character of the plant as a whole is more important than the character of any individual fruit upon it. We should therefore expect better results in earliness by selecting fruits from an early plant rather than by selecting early fruits from an ordinary plant.

10. *Products of Mature and Immature Fruits.*—In March, a fully ripe fruit, and one which was full grown and was about to begin to color, were selected from a house-grown plant of the Brick tomato—a large, regular, red variety. Plants were grown from each lot of seeds.

TABLE XVI.—PRODUCTS OF MATURE AND IMMATURE FRUITS.

Samples.	Date of first picking.	Average no. of fruits per plant.	Average wt. of fruit per plant.	Average wt. of individual fruits.
Mature	August 8	26.0	Lbs. 12.0	Ozs. 7.4
Immature	" 22	24.7	11.1	6.9

The mature-fruit lot gave the better results, both in earliness and yield.

11. *"Leggy" Plants.*—Plants which have grown tall and spindling are known among gardeners as "leggy" plants, in distinction to those which are "stocky," or short and stout. Leggy plants usually give very poor results in the field when set in the ordinary manner; but some growers obtain good returns from them by laying the stem upon the ground or in a little trench, when setting, and covering it with earth, allowing only a few inches of the tip to protrude. This treatment prevents the breaking of the plant by the wind, and roots will form along the buried portion which may aid in the production of a crop of fruit. This system was tried last year, but the layered leggy plants gave less results than normal plants set in the ordinary fashion, but they gave better results than leggy plants not layered. Our leggy plants last year were very poor, however; they were so badly drawn that they could scarcely stand alone. This year the effort was repeated, but the drawn or leggy plants, while tall and slender, were still able to support themselves, and they were vigorous. The lots for this year's test came from Ignatum seeds sown February 12. All the plants were transplanted at the same times, March 4, April 4, May 2, and were set in field June 1. Lot No. 1 was transplanted into pots at the first shifting. At the date of setting in the field they were in 4-inch pots, and were short,

stocky plants of ordinary dimensions. Lot 2 was also grown in pots of the same sizes, but the plants stood amongst a general collection of other plants, and because of lack of room and light, ran up 18 or 20 inches high. Lot 3 was grown entirely in flats, being given more room at each shifting, but the plants were allowed to grow 18 or 20 inches tall from crowding. Lot 1 was set in the field in the ordinary manner. Lots 2 and 3 were trimmed of their lower leaves, the root was set at the ordinary depth—three to four inches—and half the length of the slender stem was laid down and covered in a trench of the same depth, the free portion lying nearly parallel with the surface of the ground. The following figures show how all these lots behaved :

TABLE XVII.—“LEGGY” OR DRAWN PLANTS.

Lots.		First pick- ing.	Average no. fruits per plant.	Average wt. of fruit per plant.	Average wt. individual fruit.
1	Check. Normal setting	August 8	12.	Lbs. 4.3	Ozs. 5.8
2	Leggy, pot-grown.....	" 8	19.5	7.3	6.
3	" flat-grown.....	" 22	12.2	4.4	5.8

These figures show plainly enough that the layered leggy pot-grown plants gave decidedly best results, and that even the flat-grown leggy plants gave slightly heavier yield to frost than normal plants, although they came into bearing later. If these figures are to be relied upon, there is some advantage in growing tall and slender plants and then laying them down in setting; but the test needs to be repeated, and it should also be said that the plants, while leggy, were still vigorous.

12. *Shearing Young Plants.*—It is a frequent practice to shear the tops off young tomato plants to make them stocky, in place of a transplanting. Two dozen *Ignotum* plants, for which seeds were sown January 19, were distributed into two lots. One lot, which we may call No. 1, was transplanted on February 1, March 3, April 14, and May 17; the second lot was treated the same way except that in place of the last transplanting, May 17, the plants were sheared. At this time the plants were some 15 inches high, and about three inches of the top was cut off.

TABLE XVIII.—SHEARING YOUNG PLANTS.

Lots.	First picking.	Average no. fr'ts per plant.	Average wt. fruit per plant.	Average wt. individual fruits.
1. Normal	July 27	26.2	8.8 lbs.	5.4 ozs.
2. Sheared	Aug. 29	23.6	9.6 "	6.5 "

There was considerable loss in earliness in the sheared lot, but a gain in weight of crop before frost. This gain was not great, and too much dependence should not be placed upon it.

13. *Hilling*.—Two plots of 28 good Ignotum plants each, were set aside for a test of the value of hilling tomatoes, half of each plot being hilled July 2, the remaining halves receiving common level cultivation. The soil was drawn up around the base of the plant to a height of six inches, as potatoes are hilled.

TABLE XIX.—HILLING TOMATOES

A. YIELD TO FROST.			
Plot.	Average no. of fruits per plants.	Average wt. of fruit per plant. Lbs.	Average wt. of individual fruits. Ozs.
1 { Hilled	24.6	11.0	7.2
1 { Not hilled	24.6	9.8	6.4
2 { Hilled	20.5	8.5	6.6
2 { Not hilled	25.0	10.1	6.4
B. TOTAL FOR SEASON.			
1 { Hilled	56.4	17.9	5.2
1 { Not hilled	86.2	27.1	5.0
2 { Hilled	72.6	22.2	4.8
2 { Not hilled	61.0	18.7	4.9

The results are conflicting, although on the whole the normal or check plants gave rather the better results. In earliness there was no appreciable difference. This hilling experiment was first made last year, it having been urged upon us by a gardener who thinks that hilling gives greatly increased yields. But in both years we have found no advantage in it.

14. *Trimming*.—It is sometimes said that trimming or heading-in tomato plants in the field is an advantage, giving earlier

and heavier crops. We have tried it three years. This year, four plots of a dozen plants each of *Ignotum* were selected for treatment, three of the plots being trimmed, and the remaining one having only common treatment. The trimming consisted in heading-in the main shoots to the first fruit which had attained the size of a marble. From four to eight inches of the shoot was therefore removed. The trimming was done at different times, as recorded below :

TABLE XX.—TRIMMED PLANTS.

Plot.	Average no. of fruits per plant.	Average wt. of crop per plant.	Average wt. of individual fruits.
1. Trimmed July 28, Aug. 8 and 30	20.2	Lbs. 7.7	Oss. 5.7
2. Trimmed Aug. 8 and 30.....	20.4	7.6	6.0
3. Trimmed Aug. 30.....	24.6	9.3	5.9
4. Check.....	24.2	9.1	6.1

The early trimmed plants gave considerably less yield than the late trimming or the check. There was no constant difference in earliness. The figures, as they stand, seem to teach that the plants had better not have been trimmed, for although there is a trifle gain in the late-trimmed lot (No. 3), the increase is not enough to make one feel sure that it is due to the treatment. In 1890, however, trimming on July 28 and August 25 gave considerably increased productiveness and earliness. In 1891, the trimmings were made August 3, August 24 and September 18, and the results were indifferent ; it was then thought that the unsatisfactory yields were due to the lateness of the trimming, but the first trimming this year was made on the same date as in 1890, but with opposite results. So we are still in doubt as to whether trimming promises any benefit ; but it is evident that it does not yield decided results.

15. *Single-stem Training*.—A good number of *Ignotum* plants were set a foot apart in rows, and each plant was tied up to a perpendicular cord, but one stem or stalk being allowed to grow in each case. The first tying of the stem to the wire was made July 20, the plants having been set June 1. Probably earlier

attention should have been given to this. Thereafter the plants were tied every week or two, as occasion required, but this attention was not arduous. Other plants of same age and variety were set alongside, 4x4 feet apart, for comparison.

TABLE XXI.—SINGLE-STEM TRAINING.

Samples.	Crop previous to Aug. 31			Crop for the season.		
	Av. no. frts per plant.	Av. wt. of crop per plt.	Av. wt. of ind. fruits.	Av. no. frts per plant.	Av. wt. of crop per plt.	Av. wt. of ind. fruit.
1. Single-stem training.....	2.9	1.08	5.9	10.7	4.0	6.0
2. Ordinary planting or check...	2.8	1.04	5.8	24.2	9.1	6.1

The second column, in each instance, shows the total yield. The trained plants gave earliest results, averaging 1.08 lbs. to the plant up to the last of August, against 1.04 lbs. from the check lot; and this difference is important because the trained plants have much less bearing surface than the others. The total product for the season is nearly half as much to the plant (4 lbs. as to 9 lbs.), but the trained plants occupy five times, and more, less ground than the others, so that the yield per acre or per square yard is two or three times greater from the trained plants. These results match those obtained last year. This is the method pursued in forcing tomatoes for winter fruit where the greatest possible yield must be produced. Both last year and this we found less fruit-rot upon the trained plots than upon others. We feel safe in recommending single-stem training for home cultivation of the tomato, and we believe that it can be made profitable for the early crop in market plantations. The plants can be tied to stakes, to cords stretched up and down between two horizontal wires, or to any support which the grower may fancy. The important points are to let but one stalk grow, and to keep it securely tied to its support.

16. *Fruit-rot.*—It is well known that the rot of the fruit is influenced to a considerable extent by the method of growing and training the tomato. Single-stem training, as discussed above, usually lessens the rot, and so does any system of training which

keeps the plant open and dry. Last year we found that weak plants—those which had been poorly handled before setting in the field, and which had no fertilizer—gave more diseased fruits than those which were strong and vigorous and had been well fed. The plants set very early in the field also gave more rot than those set in June. It is impossible to say, however, if these variations were due to the treatments, or if they were merely incidental. Accurate observations were made this year in all our tomatoes, and the most important of them are tabulated below :

TABLE XXII. FRUIT-ROT UNDER VARIOUS TREATMENTS.

1.	Land heavily manured in spring with stable manure.....	8.2	per ct	rot.
2.	" " " " fall " " " ".....	14.0	"	"
3.	" fairly rich, no manure nor fertilizer.....	6.2	"	"
4.	" same as 3, one application nitrate soda (1, Table I)....	6.6	"	"
5.	" " " four applications nitrate of soda (2, Table I) 9.3	9.3	"	"
6.	" " " " " " (3, Table I) 7.0	7.0	"	"
7.	" fair, with nitrate of soda (1, Table IV).....	5.5	"	"
8.	" " " bone-black (2, Table IV).....	4.1	"	"
9.	" " " muriate of potash (3, Table IV).....	8.3	"	"
10.	" " " nitrate and bone-black (4, Table IV).....	16.6	"	"
11.	" " " nitrate and muriate potash (5, Table IV)....	8.2	"	"
12.	" " " muriate and bone-black, (6, Table IV).....	8.7	"	"
13.	" " " all three above (7, Table IV).....	14.1	"	"
14.	" " no treatment (8, Table IV).....	11.9	"	"
15.	" good, earliest setting, May 7 (1, Table VII).....	4.5	"	"
16.	" " second setting, May 9 (2, Table VII).....	10.0	"	"
17.	" " general setting, June 1 (3, Table VII).....	5.4	"	"
18.	" " earliest sowing, Jan. 19 (1, Table IX).....	13.7	"	"
19.	" " second sowing, Feb. 12 (2, Table IX).....	8.0	"	"
20.	" " third sowing, Feb. 24 (3, Table IX).....	6.3	"	"
21.	" " late sowing, Mar. 14 (4, Table IX).....	8.4	"	"
22.	" " once transplanted (1, Table XI).....	5.2	"	"
23.	" " three times transplanted (2, Table XI).....	3.7	"	"
24.	" " flat-grown, late (1, Table XII).....	7.6	"	"
25.	" " pot-grown, late (1, Table XII).....	7.8	"	"
26.	" " flat-grown, early (II, Table XII).....	8.5	"	"
27.	" " pot-grown, early (II, Table XII).....	7.2	"	"
28.	" " normal plants (1, Table XVII).....	13.2	"	"
29.	" " leggy plants, pot-grown (2, Table XVII).....	8.5	"	"
30.	" " " flat-grown (3, Table XVII).....	8.1	"	"
31.	" fair, single-stem training (1, Table XXI).....	7.0	"	"
32.	" " check (2, Table XXI).....	9.7	"	"

There are no constant variations in these figures, and apparently nothing to show that the cultivation exerted any influence upon rot. If these various treatments determine to any extent the prevalence of rot, the results were probably obscured this year because rot was everywhere very slight in our plantations.

Following is a record of the amount of fruit-rot in different varieties grown this year :

TABLE XXIII.—FRUIT-ROT IN VARIETIES.

Ignotum.....	7.0	per cent. rot.
Long Keeper.....	7.1	" " "
Nichol No. 5.....	5.2	" " "
Trophy.....	7.0	" " "
Plentiful.....	8.1	" " "
Telegraph.....	16.0	" " "
Belmont.....	10.0	" " "
Royal Red.....	5.5	" " "
Picture Rock.....	3.2	" " "
Yellow Plum.....	$\frac{1}{2}$	" " "

The amount of rot is not great except perhaps in Telegraph and Belmont, and it is probably not chargeable to the peculiarities of the given varieties, except in the instance of the Yellow Plum. In Table XXII, above, all the entries are Ignotum, and it will be seen that the figures run from 3.7 to 16.6 per cent.

Altogether, therefore, we are able to draw no definite conclusions from this year's studies of fruit-rot, largely, perhaps, because the disease was not sufficiently severe to emphasize itself in particular treatments.

17. *Southern or Field Blight*.—The accompanying illustration shows a trouble which was serious upon some of our tomatoes this year. The leaves become dull or slightly yellowish and curled, as if suffering from drouth, and the ends or individual leaflets shrivel and droop and finally become dry and black. The uppermost leaf in the engraving shows the shrivelled, dead and spindling extremity in a characteristic manner; and the lowest leaf shows the injured portion in an early stage of the disease.



The middle leaf has not reached its normal size, and looks as if it were suffering from lack of water. This trouble is probably

the disease described as the Southern blight by Professor B. D. Halsted, in Bulletin 19, of the Mississippi Experiment Station. Specimens were sub-

mitted to Professor Halsted, who thinks that the disease is probably identical with the Southern one.

This is not the first record of the occurrence of the disease in the north. In

a recent issue of *Garden and Forest*,* Professor

Halsted reports it from Syracuse, N. Y., where

Southern or Field Blight of the Tomato.

it had invaded three tomato fields. Apparently the same disease has been reported to me from three localities in this state during the last two seasons, and in two

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cases it had practically ruined the crop. This disease is probably due to a microbe, and it is therefore doubtful if spraying will be effective. Professor Halsted thinks that the same disease is one of the blights of the potato. Infected vines should be gathered and burned in the fall, and as a precautionary measure tomatoes or potatoes should not be grown upon the same land for two or three years.

18. *Impressions of Varieties*.—The Ignotum is still our best main-crop tomato.

Among the new kinds, a variety called Nichol No. 5, sent us by A. M. Nichol, Granville, Ohio, was the best. It is scarcely distinguishable from Mikado in foliage and fruit, except that the fruit is more regular and uniform in size.

Plentiful (Perry & Co.). A good red tomato, from medium to large in size, but inclined to crack about the stem. Appears to possess few superlative merits. An English variety.

Telegraph (*Salzer, 1891*). A medium to small tomato, irregular, not uniform in size and shape; cracks very badly. A weak grower. Worthless with us.

Picture Rock (*Childs*). A good, dark red, regular tomato, much like the Volunteer, but apparently no improvement upon that variety. There is a slight tendency upon some fruits to assume yellow markings, in bars, about the stem.

Royal Red (*Livingston*). A good red tomato, showing a tendency to angular fruits, like those in cultivation some years ago. It reminds one of the Valencia Cluster, which was popular six and ten years ago.

Belmont (*Breck*). A promising, regular, red tomato, uniform, early and productive.

The following table shows the earliness and yields of these varieties :

TABLE XXIV.—VARIETIES.

Variety.	First picking.	Average no. fruits per pit.	Average crop per plant.
Nichol No. 5.....	Aug. 8.....	24.4	9.4 lbs.
Plentiful.....	Aug. 22.....	15	5.2 "
Telegraph.....	Aug. 22.....	32.7	6.7 "
Picture Rock.....	Aug. 8.....	23.2	6.4 "
Royal Red.....	Aug. 8.....	23.6	8.3 "
Belmont.....	Aug. 1.....	24.1	7.4 "

We tried no introductions this year which give promise of unusual merits. In order to determine the character of the varieties now prized in Germany, we sent to a leading seed firm there for the six best market varieties of tomatoes. The varieties received were Paragon, King Humbert, Yellow Plum, Earliest Dwarf, Monstrous Giant, and French Upright. Of these, only the Paragon would be considered of any value in America for market cultivation. The Earliest Dwarf and Monstrous Giant, which are second best, represent the old angular sorts which we have long since outgrown. A



German Striped Tomato.

singular German variety is that shown in the accompanying engraving, and which may be called the German Striped. It comes to us under the name of *Niedriche Gestreifte*, or "Low Striped." It belongs to the old angular type of tomatoes. The ground color is a deep clear red, and

this is overlaid with splashes and bands of bright orange. Sometimes the orange is the prevailing color and the red takes the position of stripes. The fruit is very striking and its quality is also good. In general productiveness and merit it will probably rank fully as good as General Grant, which was popular a few years ago. We first grew this German Striped tomato in 1887. Striped or variously marked tomatoes occasionally appear in plantations, but this is the only one which we have ever known to be permanent, or to "come true to seed" for any length of time. A striped tomato appeared in an Ithaca garden three or four years ago, but it ran out in one or two generations.

The Currant-Ithaca hybrid which was described and figured

last year, was grown again this year from seeds and cuttings from one of the original plants. Among 36 plants, there were no reversions to either parent, although about one-third of them gave larger fruits than the others. All the plants were very productive and vigorous, and the fruit is very handsome.

SUMMARY.

1. *Quick and Slow Fertilizers.*—This year's experiments confirm those of last year in showing that tomatoes need a fertilizer which is quickly available early in the season. Fertilizers applied late or which give up their substance late in the season, give poor results because they delay fruitfulness and the plant is overtaken by frost before it yields a satisfactory crop. This fact is no doubt the origin of the wide spread opinion that the tomato crop is injured by heavy manuring. Nitrate of soda applied at once early in the season gave a much heavier yield than the same amount applied at intervals. (Page 189.)

2. *Value of Nitrate of Soda.*—Upon fairly good soil, which contains some vegetable matter, nitrate of soda gives good results as a tomato fertilizer. We have formerly found that upon very poor soils it gives little or no benefit. It must be remembered, however, that nitrate of soda is an incomplete fertilizer and that it should not be relied upon for a permanent treatment of land. It is simply a source of nitrogen. (Page 193, 196.)

3. *Relation of Variety to Fertilizing.*—In 1891 our test seemed to indicate that the highly improved varieties give the greatest response to fertilizing in the number of fruits produced, although the little improved sorts gave greater proportionate increase in total weight of crop. In 1892 these results were not verified, save that the little improved sorts gave least increase in number of fruits. But in the experiments of 1892 the test was made upon good soil, in which the results of fertilizing were obscured. (Page 196).

4. *Comparative Values of Early and Late Settings.*—Experiments this year confirm those of 1890 and 1891 in showing that very early planting in the field is advisable. Even those plants which were slightly injured by frost nearly equalled in produc-

tiveness those set at the general planting June 1. The late planting gave better results at the first pickings, however. Our earliest satisfactory setting this year was made May 9. (Page 197).

5. *Early and Late Seed Sowing*.—Tomato seeds were sown from January 19 to March 14. The earliest sowings gave the earliest fruits, but the largest yield came from the latest sowing, March 14, the difference in favor of this late sowing being very marked. In 1889, our tests showed that seeds sown in April and May gave poorer results than those started in March. It seems to be true, therefore, that the best time to sow tomato seeds in this latitude for the main crop, if one has a forcing-house or a good hot bed, is about the middle of March. (Page 200.)

6. *Few and Several Transplantings*.—Earlier fruits were obtained from plants which had been three times transplanted in the house than from those transplanted only once. In 1891, greater yields were obtained from two transplantings than from either one or three. Much, no doubt, depends upon the vigor and age of the plants, but it is certainly safe to say that in all ordinary cases plants which are started in March should be transplanted at least twice. (Page 202.)

7. *Flat-grown vs. Pot-grown Plants*.—Plants grown in pots, one lot transplanted twice and one lot thrice, gave earlier and heavier yields than plants similarly transplanted into "flats," or shallow gardener's boxes. (Page 202.)

8. *Seedlings vs. Cuttings*.—This year, cuttings gave earlier and heavier yields than seedling plants. In 1890, the cuttings gave the poorer yields, while in 1891 the results were mixed. These variations in results no doubt depend upon some condition of the plants or some factor in our handling which we have not yet discovered. Cuttings of cuttings gave better yields than one-generation cuttings, both last year and this. (Page 203.)

9. *Products of Early and Late fruits*.—Plants grown from seeds from the first ripe fruit upon a given plant gave poorer yields and no earlier fruits than other plants grown from a fruit from the same parent which ripened three and a half months later. Similar results have been obtained before by ourselves and others, and it is probably safe to say that no gain is secured by selecting seeds from early or first ripe fruits without giving any attention to the character or habit of the plant as a whole. (Page 205.)

10. *Products of Mature and Immature Fruits.*—Plants grown from seeds from a fully ripe fruit gave earlier and better yields than other plants raised from a fully grown but unripe fruit from the same parent. (Page 207.)

11. *Treatment of "Leggy" Plants.*—"Leggy" or "drawn" plants were set at the ordinary depth and half the stem was laid and covered in a shallow trench. These gave much larger yields than normal or stocky plants started and planted at the same time. Last year opposite results were obtained; but at that time the plants were so badly drawn that they were unable to stand alone. This year the leggy plants were about 20 inches high, but while slender they were still stiff and vigorous when put in the field. It is safe to conclude that if one has leggy plants he should layer them when planting. (Page 207.)

12. *Shearing Young Plants.*—Plants which were sheared to make them stocky, in the place of one transplanting, were later than others which were transplanted at the date of this shearing. The yields were slightly in favor of the sheared plants, but this may have been an incidental variation. (Page 208.)

13. *Hilling Tomatoes.*—Hilling tomato plants, during two years, has given no favorable results. (Page 209.)

14. *Trimming Tomato Plants.*—Trimming the plants after they have made a good growth in the field gave no advantage this year, and it is doubtful if it is advisable. (Page 209.)

15. *Single Stem Training.*—This year, as last, single-stem training in the field gave decidedly heavier yields to the square foot of land, and the crop was earlier. (Page 210.)

16. *Fruit-rot.*—Rot was not serious this year, and it did not appear to be influenced by methods of cultivation or varieties. (Page 211.)

17. *Southern or Field Blight.*—A new tomato disease appeared in our plantation this year. It is probably a bacterial trouble which may become serious. No remedy is known, but rotation of crop will probably check it. It is characterized by a yellowing, curling and drying of the leaves, which finally become black and dead. (Page 213.)

18. *Varieties.*—Few varieties were tested in 1892, and while they possess merit, none of them appear to be destined to supplant varieties already in existence. (Page 215.)

L. H. BAILEY,
L. C. CORBETT.

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Cornell University Agricultural Experiment Station

HORTICULTURAL DIVISION.

MULBERRIES.



By L. H. BAILEY.

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BULLETINS OF 1892.

38. The Cultivated Native Plums and Cherries.
39. Creaming and Aerating Milk.
40. Removing Tassels from Corn.
41. On the Comparative Merits of Steam and Hot Water for Greenhouse Heating.
42. Second Report upon Electro-Horticulture.
43. Some Troubles of Winter Tomatoes.
44. The Pear-Tree Psylla.
45. Tomatoes.
46. Mulberries.

MULBERRIES.

The mulberry is a neglected tree. It possesses decided value in ornamental planting, and some of the varieties are useful for hedges, shelter-belts and small timber. The fruit has merit for the dessert, and it is easily grown and is produced more or less continuously throughout a period of two to four months of every year. It is this value of the mulberry as a fruit-bearing tree which I particularly wish to discuss in this paper. Perhaps there is no immediate prospect that the mulberry can be grown with profit for the market because there is no demand for it, but it is capable of adding so much to the charm of the home garden and orchard that I desire to urge it upon the attention of every land owner. The botanical relationships of the various forms are also perplexed and they demand attention before any intelligent discussion can be made of their horticultural merits ; but this subject is so difficult that I enter upon it with caution. No group of cultivated plants has bothered me more, and three years of study and collection of material appears only to have augmented the perplexities. Of all fruits cultivated in America, I think that none have so meagre a literature as the mulberries. There is an abundant record of the early attempts towards silk culture in this country and the mulberries which were grown for feeding the worms, but with the failure of these attempts the mulberry nearly passed from sight. There are men still living who remember the "multicaulis craze" of the thirties. Perrottet had introduced a new mulberry into France from the Phillipines in 1824, the large leaves and rapid growth of which at once attracted the attention of all silk-growers. It turned out that this tree had come originally from China and was the source of the famous Chinese silk. Perrottet called it *Morus multicaulis* from its habit

of branching or sprouting from the surface of the ground. This tree reached America in 1829 or 1830, by way of the nurseries of Messrs. Prince, on Long Island, and in 1830 or 1831 it was introduced into Massachusetts by William Kenrick, author of the "New American Orchardist." The fame of the tree spread rapidly, and there arose a fever of speculation such as has never been known in any other horticultural venture in America. The records of the next ten years read like fiction. Many nurserymen gave up all other business that they might grow the mulberry, and they realized several hundred per cent. profit. The secret of the Chinese silk had been discovered and every available acre from New England to the Gulf must be covered with the marvellous herbage of this mulberry, and men must train their hands to the breeding of the worms and spinning the silken threads! One nurseryman, who is still living, went to the West Indies that he might grow hundreds of thousands of trees during the winter season, so great was the haste for plants. From the thinly settled portions of the west the planters came eager for trees at almost any price, and even in Maine the demand was great. Then came the reaction. The market was supplied and soon over-stocked. A disease appeared. The winters of New England were too severe. One man near Hartford lost nearly ten thousand trees from cold. Men lost their fortunes; and in 1839 the bubble burst. One man near Philadelphia sold 250,000 trees at one auction in the fall of that year. He realized 31 cents each with a discount of $7\frac{1}{2}$ per cent. for cash. His buyers were mostly from the west. The eastern men had grown cautious before this. Other dealers sold for much less, and many had thousands of trees left upon their hands. "The trees were sold, in some instances, for a few cents each, and thousands, if not millions, were never replanted after they had been taken out of the ground in the fall of 1839." So *Morus multicaulis* passed from sight and the present generation knows nothing of it. No nurseryman grows it. The last specimen in the east, so far as any one knows, was cut down nearly ten years ago. It stood on the old battle ground at Germantown. Only one tangible result of this great contagion remains to us. Charles Downing, whose name will long remain a household word among those who love gardens and

fruits, planted seeds of this mulberry and raised the Downing Mulberry, which is now grown for its fruit.

This was not the beginning of American mulberry cultivation, although it was far the most important contribution to it. Before this time various forms of mulberries had been introduced, but mostly for the purpose of feeding silk worms. Benjamin Franklin had demonstrated that good silk can be grown in this country. M'Mahon, 1806, had urged the cultivation of the mulberry for fruit and for hedges as well as for silk. In 1806, too, Frederick Pursh, a botanical traveler, found mulberries cultivated in orchards near Cayuga Lake, N. Y., "may be for the raising of silkworms, as the trees were low and planted in regular close rows." William Prince, in 1828, regarded the Black Persian and the wild native red mulberry as the best for fruit, and he enumerates several kinds for silk. Among other sorts which were introduced in the early days was *Morus Tatarica*, which has lately reappeared as the Russian mulberry. So far, there appear to have been no varieties of any species of American origin. It is a significant fact that the first named variety originating in this country is an offspring of our own wild *Morus rubra*. This is the Johnson. The first mention of it, so far as I know, is in the first edition of Downing's "Fruits and Fruit Trees" in 1845.

I have said that the botany of the mulberries is perplexing. This is notoriously the case in every country where they are cultivated. There appear to be three well marked general types in cultivation, the white, black and red,—*Morus alba*, *M. nigra*, *M. rubra*. I must warn my readers that these names do not designate the color of the fruits of the respective species, although they were no doubt meant to distinguish them. Our native *Morus rubra* bears somewhat redder fruits than the others; fruits of the black mulberry are black, but so are those of the white mulberry in many cases. Perhaps we can apply the terms white and black in a general way to the color of the foliage, as that of *M. alba* is much lighter than that of *M. nigra*. The white mulberry is the species most used for silk. It has been cultivated in many countries for many centuries, and, as a consequence, it is wonderfully variable. Bureau, in his monograph of the genus in 1873, refers 31 described species to *M. alba* and recognizes 27

botanical varieties or types of it. But it is difficult, in some cases, to distinguish between *M. alba* and *M. nigra*, and if we are to follow Bureau's classification I do not see how the two can be kept apart, for some of the plants which he refers to *M. alba* seem to be as distinct from its type as *M. nigra* is. In this paper I have kept apart two species which are commonly referred to *Morus alba*. I do not know if they are distinct species, but they are more easily understood if they stand by themselves; and as species at best are only judgments of the particular author who describes them and not entities in nature, I may be allowed the present arrangement.

The later American mulberry culture for fruit, scant as it is, has developed along independent lines. The black mulberry, *Morus nigra*, is the fruit-bearing mulberry of history, and nearly all writers declare that the white mulberry possesses little or no value for fruit. Yet in America the black mulberry is almost unknown, except sparingly in the south and in California, and some of our common varieties are offspring of the white mulberry. And to these must be added varieties which I am satisfied belong to our native red mulberry.

The American mulberries, so far as I know them, may be grouped under the following species, omitting the kinds which were early cultivated for silk and are now practically unknown in the country:

1. The White Mulberry group.—*Morus alba*.
 1. (a). Russian mulberry.—Var. *Tatarica*.
 1. (b). Nervosa mulberry.—Var. *venosa*.
2. The Multicaulis group.—*Morus latifolia*.
3. The Japanese group.—*Morus Japonica*.
4. The Black Mulberry group.—*Morus nigra*.
5. The Red or Native Mulberry group.—*Morus rubra*.
 5. (a) Lampasas mulberry.—Var. *lomentosa*.

1. THE WHITE MULBERRY GROUP.—(*Morus alba*, Linn.) Leaves light green, rather small, smooth or very nearly so above and often shining, the veins prominent beneath and whitish, variously lobed or divided, the basal lobes unequal, the teeth large and for the most part rounded or nearly obtuse, the branches gray or grayish-yellow. The white mulberry is supposed to be a na-

tive of China. It has been cultivated from the earliest times, chiefly for feeding the silk worm. It is a frequent tree along roadsides and in the old yards in the eastern states, where the trunk sometimes attains a diameter of two feet. This half-wild form usually has rather small rounded shining leaves with very large rounded teeth, and bears little whitish or violet fruits which are very sweet. Sometimes the fruits are an inch long, but they are oftener only half that length, and I sometimes find trees upon which the fruits are barely a quarter of an inch in length. Now and then a tree bears fruits nearly or quite black. Birds, poultry and hogs are fond of these mulberries. The trees are usually very thick-topped and bushy growers, but occasionally one is seen which, when young, has branches as straight and trim as a Northern Spy apple. These half-wild trees are seedlings, and this accounts for their variability. If the best ones were selected and grafted onto others, we might find trees worthy of orchard culture. This, evidently, has been done in some cases, for the three following named varieties differ from these half wild mulberries chiefly in their straighter growth, and larger and blacker fruit.

New American.—This variety was brought to notice by N. H. Lindley, Bridgeport, Conn., about 1854. No one knows its parentage. It is now widely cultivated, and it is the best mulberry yet known for the northern states. It is a strong, hardy tree, very productive, and bears continuously from late June until September. Large trees will produce ten bushels of fruit in a season. The fruit ranges from an inch to over two inches long, and it is glossy black when ripe. The accompanying picture shows a spray a little over half size. The fruit in this specimen is small. Notice the rounded teeth on the leaves, which are usually characteristic of these forms of *Morus alba*. The Downing has a greater reputation than any other variety, and this New American is often sold for it. In fact, the true Downing is now rare in cultivation. But this point will be discussed under the Downing, further on.

Trowbridge and Thorburn.—I do not know the origin of these mulberries. They are very like the New American, with a tendency, perhaps, towards a sharper toothing of the leaves. Some good judges declare that all three are alike, but I think that they are distinct. At least, I believe that the last two are

distinct from the New American. And there is some reason for supposing that Trowbridge and Thorburn are distinct. A party of botanists, to whom both varieties were new, were asked to pick and eat fruit from the two kinds last summer. They agreed



New American Mulberry.

that Trowbridge is slightly more acid than Thorburn and has more pronounced flavor. But so far as I know, these two varieties possess no merits above the New American and they are little known.

I. (a) THE RUSSIAN MULBERRY SUB-GROUP.—*Morus alba* var. *Tatarica*, Loudon. (*Morus Tatarica* of Linnæus).

This is a hardy type of *Morus alba* which was introduced into our Western States during 1875-'6-'7 by the Russian Mennonites. It scarcely differs from the type of *Morus alba* in botanical characters, and perhaps should not be kept distinct, even as a botanical variety. As commonly seen, it is a low-growing very bushy-

topped, small tree with small and much lobed leaves.

The fruit is usually very small and insipid, and varies from creamy white to violet, deep red and almost black.

The accompanying picture of the Russian Mulberry appeared in the *American Garden* some two years ago. It was made from a specimen taken early in the season from the Cornell garden.

The Russian Mulberry is commonly propagated from seeds and it is therefore very variable. A large-fruited or distinct-growing form often appears, and three, at least, of these have been named. They are described below.



Russian Mulberry.

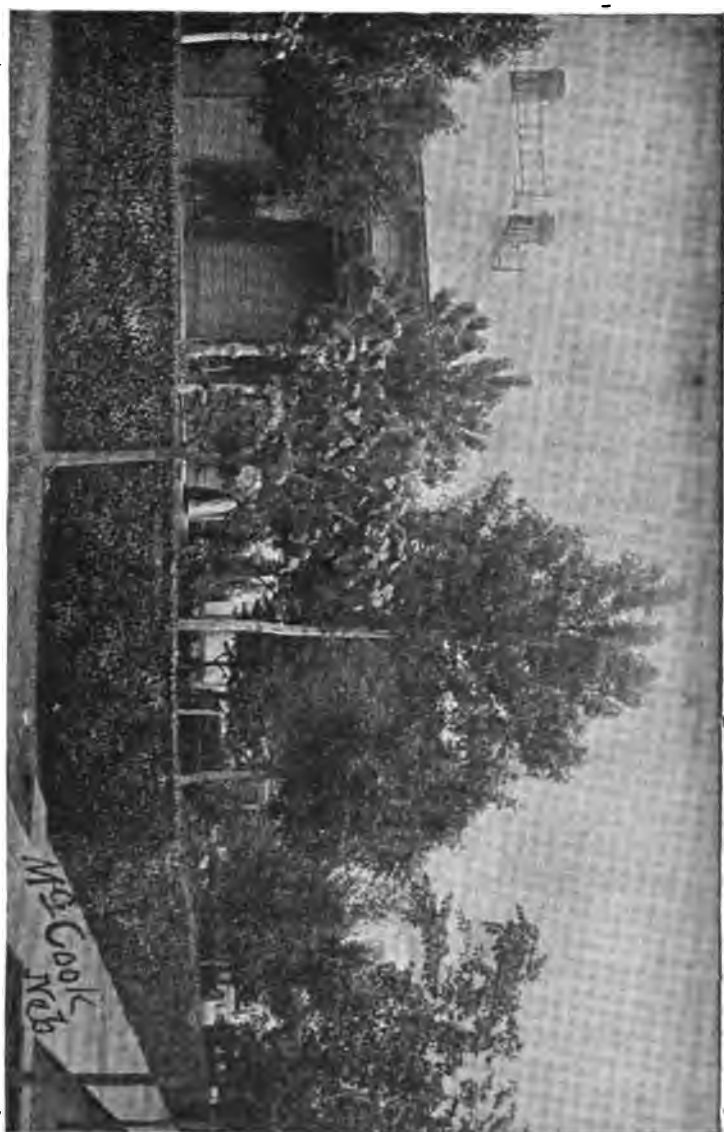
The irritation which the Russian mulberry has produced reminds one of the multicaulis fever of sixty years ago, but it is far less serious and wide spread than that disease. This Russian mulberry has suffered from indiscriminate and exaggerated praise. Save an occasional sport, it has no merit for fruit, unless it serves to attract birds from cherries and other fruits, but even this is a problematical advantage. In the east, at least, it has no merits for timber, as it is too small and grows too slowly. In the prairie soils of the west it often grows into respectable post timber in a short time. Mr. I. Horner, of Emporia, Kansas, writes as follows, concerning it :

"It has been said that this tree is only a bushy shrub. I here exhibit to you a section of a Russian mulberry tree five years old, and which has been grown in a shelter belt and overshadowed with cottonwood trees. It is five inches in diameter, and, as you see, a nice, straight and smooth trunk eight or nine feet

long. Another year's growth would make it suitable for posts. I measured one tree which gave a circumference of $37\frac{1}{2}$ inches at a point two and a half feet above the ground, and which was only eight years old. * * It is one of the very best trees for shelter belts and fence posts. From a hedge-row 15 rods long, I saw 200 nice fence posts cut. The wood is very durable. * * * *
* It is a tree for fuel, shelter and posts for the western prairies." "There is a vast difference in character of growth and quality of fruit. Most trees sold by nurserymen have been grown from seed gathered from mulberry hedges and trees, with no regard to quality of tree, and which naturally generates a large per cent. of inferior stock. These may be known by a disposition to branch freely close to the ground, and a drooping inclination of their growth. They bear small notched leaves, and very small insipid fruit." "Shelter belts should be constructed in rows 12 to 16 feet apart, and the trees from two to four feet in the row. When three years old, cut all level with the ground. From their roots will spring up a strong and rapid growth of shoots. Remove all but the strongest to each tree. After two years, thin out as may be desired."

The Russian mulberry has been allowed by some land offices as a timber tree under the timber claim law.

But the chief merit of the Russian mulberry appears to be its value as a hedge plant in cold regions. Mr. Rosenberger of Nebraska makes the following note of it in a recent issue of *American Gardening*: "The Russian mulberry does not make a serviceable hedge to turn stock, but for an ornamental hedge there is nothing that I know of equal to it, at least for the west and northwest. It endures the extremes of climate better than any other plant or tree suitable for hedge purposes." This note is accompanied by an engraving, which is borrowed for this occasion, of a Russian mulberry hedge in Nebraska. Mr. G. J. Carpenter, secretary of the Nebraska State Horticultural Society and a prominent nurseryman, writes me as follows upon this point: "Russian mulberry hedges are found in nearly every town in Nebraska. It makes one of the finest ornamental hedges. The Mennonites, when they came to this country, planted a great many of them and used them to spread their clothing on to dry, and some of these hedges are 12 and 15 years old and in good condition."



A Russian Mulberry Hedge at McCook, Nebraska.

yet. There are some very fine hedges in the western part of the state, west of the 100 meridian, that have been out for over eight years, and they are as perfect as any hedge can possibly be."

I think that the Russian Mulberry possesses considerable merit as a small ornamental tree and for the purpose of making low screens or shelter belts in the east. It is now largely used as a stock upon which to graft the named varieties of mulberry.

The named varieties or seedlings of the Russian type are three:

Victoria.—Originated in 1883, from seed of the Russian mulberry, by G. Onderdonk, of southern Texas. It is a tall and upright grower, bearing large sweet black fruit, which is in season for several weeks.

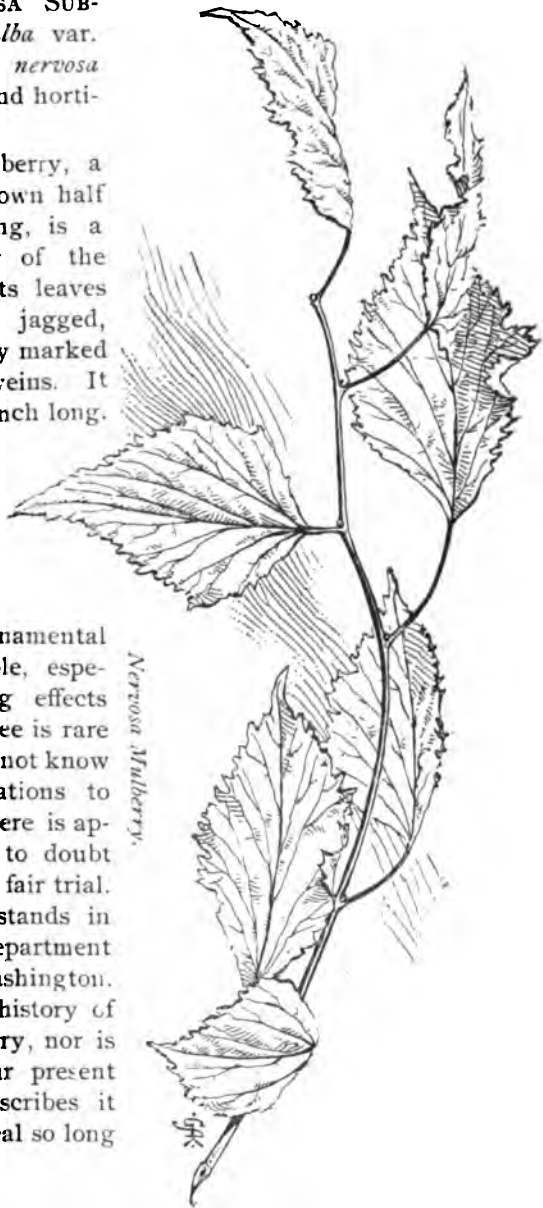
Mr. Onderdonk writes me as follows concerning it: "I named the Victoria after our county. It is proving itself of excellent quality, and is enormously productive. The more I see of it the more I am convinced that its dissemination is not a mistake. It has become very popular all over Texas, and as the Russian race of mulberries is hardy against every extreme of climate, I can see no reason why it should not spread over every part of the United States where the mulberry can exist. Whatever may be the merits of other varieties in other sections, the Victoria is their superior in this part of southern Texas."

Ramsey's White.—A white fruited mulberry which came in a lot of Russian mulberry stock from Nebraska, purchased by Ramsey and Son, Mahomet, Texas, some ten years ago. Mr. Ramsey writes me that he has "concluded that it does not equal Hicks and two other varieties which we have." It is catalogued by Mr. Onderdonk, who says: "A good white mulberry, bears young; requires some pruning to make a good shaped tree. A desirable new sort."

Teas' Weeping Mulberry.—This, the most pronounced weeper among our ornamental trees, is a chance seedling of the Russian mulberry, having come up in a nursery row nine years ago in the plantation of John C. Teas, Carthage, Missouri. The original seedling tree is still only three feet high, although vigorous. In the nursery row this seedling trailed on the ground, while all the others made the ordinary upright growth. Grafted head high upon vigorous Russian stocks, it makes a most striking lawn tree. The branches curve outwards for a foot or two and then fall straight downward to the ground.

- I (b) THE NERVOSA SUB-GROUP.—*Morus alba* var. *venosa*, Delile. (*M. nervosa* of Bon Jardinier and horticulturists).

The Nervosa mulberry, a spray of which is shown half size in the engraving, is a strange monstrosity of the white mulberry. Its leaves are contracted and jagged, and are very strongly marked with many white veins. It bears a fruit a half inch long. Among the horticultural curiosities, this tree should find a place, and it is to be regretted that it is not grown by our nurserymen. Its ornamental value is considerable, especially when striking effects are desired. This tree is rare in America, and I do not know what are its adaptations to our climates, but there is apparently no reason to doubt its success if given a fair trial. A large specimen stands in the grounds of the Department of Agriculture at Washington. I do not know the history of the Nervosa mulberry, nor is it important for our present purpose. Delile describes it in a French periodical so long ago as 1826.



2. THE MULTICAULIS GROUP.—*Morus latifolia*, Poir. (*M. multicaulis* of Perrottet. *M. alba* var. *multicaulis* of Loudon.)

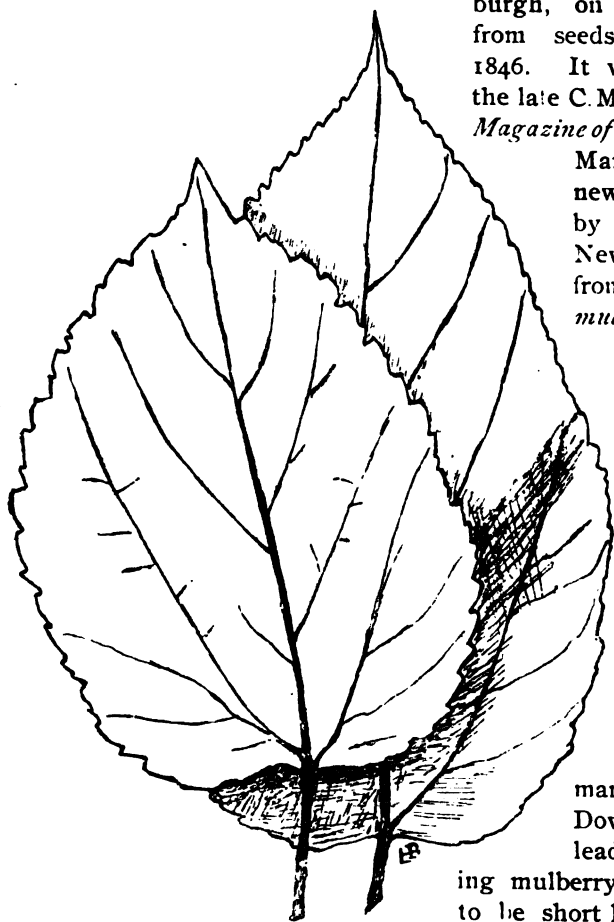
A strong growing small tree or giant shrub, with dull, roughish and very large long-pointed leaves which are seldom or never prominently lobed, and which are often convex above, bearing black sweet fruit. I have already given a sketch of *Morus multicaulis* in America. Its most prominent offspring is the

Downing (*Downing's Everbearing*).—This originated at Newburgh, on the Hudson, from seeds sown about 1846. It was noticed by the late C. M. Hovey in his *Magazine of Horticulture* in

March, 1858, as "a new seedling raised by C. Downing of Newburgh, N. Y., from the *Morus multicaulis*." The

Downing often looks very different from the old multicaulis, and I sometimes doubt if its history is correct; but there is probably no doubt as to its origin. For

many years the Downing was the leading fruit-bearing mulberry, but it proved to be short lived and was



New American and Downing Leaves.

often injured by the winters in the northern states ; and even as far south as Texas it frequently suffers from the cold. In Florida it is said to be still popular. The Downing now sold by most nurserymen is the New American, as I have already said. Only the older nurseries still grow the true Downing, so far as I have observed in the eastern states. Most planters and perhaps some nurserymen are not aware of this substitution. Some nurserymen habitually substitute the New American for the Downing, using the latter name, saying that they are disseminating a better variety. It is true that the New American is the better of the two, at least for the north, but it is unfortunate that this substitution should have occurred. Many nurserymen suppose that the two varieties are the same, but they not only differ in hardiness but also in foliage and fruit. The accompanying outlines show some of the difference in foliage. The top leaf is the New American and the under one Downing. The Downing leaf is much the larger and longer, longer-pointed, with smaller teeth. It is usually proportionally larger than shown in the engraving. It is also a duller and usually a thinner leaf than that of the New American. By referring to the first illustration in this paper, it will be seen that the fruit of the New American is made up of closely compacted parts or drupelets, while in the Downing, as seen in the cut in the margin, the drupelets are more or less detached. This picture of the Downing fruit shows a small specimen. The fruit is black, of excellent quality, possessing a slight acidity which is apt to be lacking in the varieties of *Morus alba*. The fruit ripens from June until September.

*Downing.*

Spalding.—I am indebted to T. V. Munson of Denison, Texas, for a knowledge of this variety. It is said to be a seedling of the Downing, and the leaves and habit confirm this origin. Mr. Munson says that it is as tender as the Downing. It originated with the late E. H. Spalding, who thought it the finest variety in cultivation. I do not know its fruit.

Rives.—This mulberry, which is sent me by G. Onderdonk, of Nursery, Texas, was found upon the promises of James Rives of Mission Valley, Victoria Co., Texas. Its origin is unknown.

Mr. Onderdonk thinks it is a form of *Morus Japonica*, but it seems to me to belong to the multicaulis group, although it may be the native *Morus rubra*. I have not had an opportunity to study it thoroughly. "The fruit, while being good, has not special merit," Mr. Onderdonk says. It is recommended chiefly for shade, the growth being very rapid and the leaves large. It is also said to be valuable for silk. In Texas it blooms so early that the fruit is often lost.

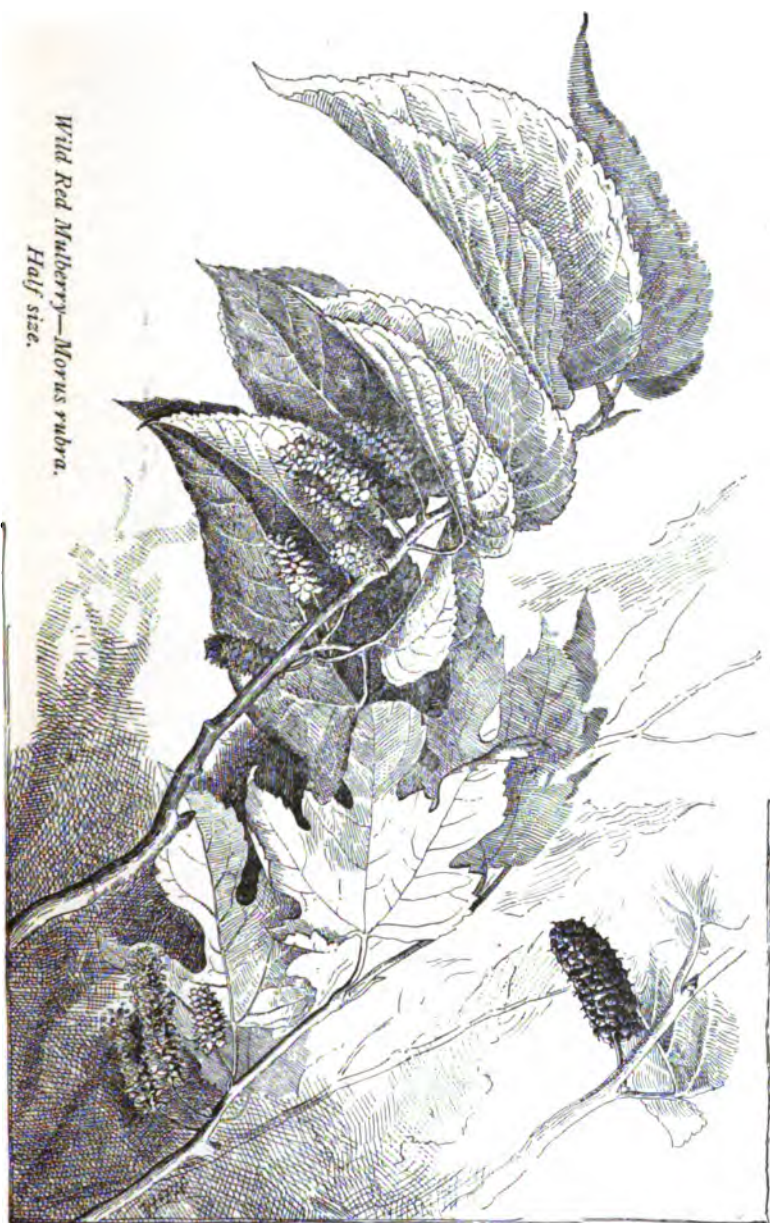
Two mulberries have recently been sent me from the University of California under the name of Lhoo—originally spelled Lhou—and Nagasaki. These, I think, belong with the multicaulis group, although they suggest *Morus Japonica*. Bureau refers some of the Chinese Lhou mulberry to *Morus alba* var. *macrophylla* (*Morus Moretti*), and some of it to this multicaulis group. At the University of California the climate is said to be too cold to allow these mulberries to fruit. These oriental varieties are grown chiefly for feeding silk worms.

3. THE JAPANESE GROUP.—*Morus Japonica*, Audibert.—(*M. alba* var. *stylosa* of Bureau.)

Leaves usually large, dull, rather thin, long-pointed, the rounded teeth very large and deep, or the margin even almost jagged, the leaves upon the young growth usually deeply lobed. This species has been introduced very lately and it has not yet fruited in this country, so far as I know. It is tender in the north when young. The fruit is described as short-oblong and red.

4. THE BLACK MULBERRY GROUP.—*Morus nigra*, Linn.

Leaves dark dull green, rather large, tapering into a prominent point, commonly very rough above, usually not lobed, the base equal or very nearly so upon both sides, the teeth rather small and close, the branches brown. The black mulberry is a native of Asia, probably of Persia and adjacent regions. It is the species which is cultivated in the Old World for its fruit. In America it is very little grown. It is not hardy, except in protected places, in New England and New York. The Black Persian mulberry of the south and of California is undoubtedly this species. This variety, with others, was inserted in the Fruit Catalogue of the American Pomological Society for 1875. It was dropped



Wild Red Mulberry—Morus rubra.
Half size.

from the Catalogue in 1883, and has not been inserted since. It is named in Wickson's "California Fruits," 1889, without particular comment. The same volume also mentions the Black mulberry of Spain, as having been fruited by Felix Gillet, of Nevada City, California. This I take to be *Morus nigra*. There must be large regions in this country which are congenial to the true black mulberry, and it is strange that it is so little known. The fruit of this species is much larger than that of any other, and it possesses an agreeable sub-acid flavor. The fruits of *Morus alba*, however, are often too sweet for most tastes when fully ripe, and in such case they should be picked before they have fully matured.

5. THE RED OR NATIVE MULBERRY GROUP.—*Morus rubra*.
Linn.

Leaves usually large, very various, those on the young shoots deeply lobed with very oblique and rounded sinuses in the base of which there are no teeth; the upper surface rough and the lower one soft or variously pubescent, the teeth medium or comparatively small and either rounded or bluntish. The native mulberry is generally distributed from western New England to Nebraska and southward to the Gulf, being much more abundant and attaining a larger size in the south. The fruit is deep red, or when fully ripe, almost black, variable in size, often very good, nearly always having an agreeable slight acidity. This native mulberry has been tried for the feeding of silk-worms, but with indifferent success. I am satisfied that at least three of the named fruit-bearing mulberries belong to it, and a yellow-leaved mulberry, which is somewhat grown for ornament, also appears to be of this species. The curious lobing of the leaves on the young growth is shown in the middle spray in the accompanying engraving (page 237). This lobing is distinct from that in any other mulberry which I have seen, and it has been one of the chief characters in influencing me to refer the Hicks and Stubbs mulberries to *Morus rubra*. The nearest approach to this lobing which I have seen in any other mulberry is in the Japanese (*Morus Japonica*) and this affords another of those interesting parallelisms which exist between the Japanese and eastern American floras. The red mulberry is the largest tree of the genus. It often attains a height of 70 feet in the south. The timber is

much used for posts, fencing and light wood-work. The two accompanying pictures are made from wild specimens collected in Michigan.

Johnson.—I have already said that this appears to have been the first named variety of mulberry, of any species, originating upon American soil. The first record of it, so far as I know, is in the first edition of A. J. Downing's "Fruits and Fruit Trees," 1845, in which it is said that the variety has been "lately received from Professor Kirtland, of Cleveland, one of the most intelligent horticulturists in the country;"

and it is distinctly stated that it is a form of our native species. Charles Downing reaffirms this latter statement in Purdy's *Fruit Recorder*, in 1872, and in comparing the fruit with that of the wild *Morus rubra* says that it is "of about the same quality, but of larger size." In the second edition of "Fruits and Fruit Trees," 1872, by Charles Downing, it is described as follows: "A seedling from Ohio. Fruit very large, oblong cylindric; blackish color, sub-acid and of mild agreeable flavor. Growth of the wood strong and irregular. Leaves uncommonly large." The Johnson is very little known at the present time and will probably soon pass from sight. Mr. Berckmans, of Georgia, writes that the "fruit is large, very good, but too little of it," and that he has "long since discarded it." "The fruit is fully two inches long by three-fourths inch in diameter, very black and of a rich vinous flavor."



Wild red mulberry. Full size.

Hicks (Hicks' Everbearing). This is a Georgian variety, as near as I can learn, although Downing, in 1872, credits it to Kentucky. It was brought to notice about 1850, or before, by Simri Rose, of Macon, Georgia, who is said to have obtained it from Thomas Elkins, of Effingham Co., Georgia. Mr. Elkins "planted it in avenues, on his lanes, in his fence corners, and many other favorite places on his plantation, for his hogs, and it is said that he always had pork or bacon to sell." At the present time it is much used in parts of the south as a food for swine. Mr. Berckmans says that "the value of mulberries as an economic food for hogs is beginning to be appreciated by many farmers, who have

planted large orchards of the Hicks for that purpose." It is also one of the very best varieties for poultry. It is a most profuse bearer, producing a continuous and bountiful crop for three and four months. The fruit is medium to large, very sweet and rather insipid.

Stubbs.—The original Stubbs mulberry tree was found growing in a wood near Dublin, Laurens Co., Georgia. Col. John M. Stubbs, of that place, gave cions to Mr. Berckmans some 15 years ago, and Mr. Berckmans introduced it to the public. It is probably the most productive of all mulberries, even exceeding the wonderful prolificacy of the Hicks. The fruit is deep black, with a very rich sub-acid vinous flavor. It is fully two inches long and over a quarter as thick in well developed specimens.

5. (a) THE LAMPASAS SUB-GROUP.—*Morus rubra* var. *tomentosa* Bureau. (*M. tomentosa* of Rafinesque.)

Leaves very soft-pubescent and whitish beneath, often glossy but rough above.

Lampasas.—This variety was found in the woods in Lampasas County, Texas, by F. M. Ramsey, and was introduced in 1889 by T. V. Munson, of Denison, Texas. It has a somewhat spreading and shrub-like habit. Mr. Munson writes as follows concerning it: "The Lampasas mulberry, although a native of the region only 200 miles southwest of here, is so tender here as to winter kill. I have ceased to propagate it on that account. I have never been able to fruit it."

There are three varieties of fruit-bearing mulberries which I have not seen, and I do not know to what species they should be referred. One is *Bigert* (*Bigert's Everbearing*), which I know only from the following note in the first volume of *Gardener's Monthly*, 1859: "A friend sends us some specimens under the above name, which he says continues in bearing from June till frost. It is very much in size and appearance like Downing's *Everbearing*, but the leaves are very different."

Another variety is the *Paine*, which, I think, has not been mentioned in print. All I know about it is the following description sent me by the venerable Isaac Hicks, of Westbury, Long Island: "Fruit about the size of Downing, not so large as New American. A very excellent variety, bearing a long time.

Found on the lot where Thomes Paine, the religious reformer, was buried. Two very fine trees, which are great bearers, are on the place of the late Wm. S. Carpenter, at Marmaroneck, Westchester Co., N. Y."

The third variety is the Black American, which I know only from the following entry in the catalogue of the Bloomington (Illinois) Nursery: "Native, hardy, productive, valuable."

The cultivation of the mulberry is very simple. It thrives upon any ordinary well-drained soil. At full maturity, the trees are as large as an apple tree. The fruit falls as soon as it is ripe, and it is readily shaken off before it reaches its full maturity. If a soft sod is allowed under the tree, the fruit can be shaken off and picked from the ground. This is the best way of harvesting the mulberry. In Europe, cress is sometimes sown under the trees in late spring to afford a temporary carpet to catch the fruit.

The mulberries can be propagated by cuttings of the ripe wood or of roots. Cuttings start best under glass. Some nurserymen propagate by short cuttings indoors, starting them in February or March. The cheap Russian mulberry stocks, from the west, have supplanted cutting-propagation very largely. The named sorts are grafted upon these Russian roots in winter, with fair success, in the same manner in which apple trees are root-grafted, or they are sometimes crown-grafted, the stocks for this purpose being grown in pots or boxes. Ordinary fall budding in the field is not successful with mulberries, but spring budding gives good results. Spring budding has been employed and recommended certainly for thirty years, but it does not yet appear to be a common practice. S. D. Willard, Geneva, N. Y., who grows quantities of mulberries, has several times shown me his stock, which is propagated by spring coin-budding. This is performed just before the foliage is out, or as soon as the bark slips freely. The illustration in the margin explains the operation. The incision in the stock is the same as for the ordinary fall budding. The coin carries one or two buds, and is cut upon one side only. This prepared side is inserted next the wood in the stock, and is held in place by string, as for fall budding.



Coin-budding for the mulberry

REVIEW.

1. The mulberry is grown for fruit, ornament, hedges and small timber, as well as for silk. It merits more general attention, especially as a fruit-bearing tree.

2. The fruit of some varieties is excellent for dessert, and it may be used for making jellies and preserves. It is also good food for poultry and for swine.

3. Sixteen varieties are mentioned in this paper as fruit-bearing kinds: New American, Trowbridge, Thorburn, Victoria, Ramsey's White, Downing, Spalding, Black Persian, Black Spanish, Johnson, Hicks, Stubbs, Lampasas, Bigert, Paine and Black American. Of these, the most prominent are New American, Downing, Black Persian, Hicks, Stubbs.

4. The New American is recommended for the northern states. Downing is almost out of cultivation in the north, but the New American commonly passes under this name. Black Persian is occasionally grown in the south and on the Pacific coast, but it seems to be ill-adapted to our conditions. Hicks is a heavy bearer, of indifferent quality, but valuable for poultry and for swine, especially in the south where it has been most thoroughly tested. Stubbs is perhaps the most profuse bearer of all, and the fruit is large and excellent in quality.

5. The other varieties and types are grown for shade, ornament and timber. The most unique of these varieties are the Nervosa and Teas' Weeping. The Russian type is valuable for ornamental hedges, especially in the prairie states, for planting sparingly as single specimens or in groups as ornamental trees, and for small timber on the prairies. The fruit is usually worthless. This type has already given three named varieties of more or less merit,—Victoria, Ramsey's White, and Teas' Weeping.

6. The mulberries here enumerated belong to five more or less distinct general types or species,—*Morus alba*, *M. latifolia*, *M. Japonica*, *M. nigra*, and *M. rubra*. The first and the last are the most important in this country for the purposes here discussed.

7. American varieties of fruit-bearing mulberries have developed along independent lines, having come chiefly from *Morus alba* and *M. rubra*, while the fruit mulberry of history is *M. nigra*.

8. The native mulberry, *Morus rubra*, has given us some of the most important varieties, and as it is naturally variable and adapted to our various climates, it is the probable progenitor of the American mulberries of the future.

9. The mulberry is easily grown upon ordinary soils. It is often tender in the north during the first two or three years.

10. The mulberry is propagated by cuttings of the mature wood or the roots, by root and crown-grafting, and by budding with dormant buds in the spring.

L. H. BAILEY.

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Cornell University Agricultural Experiment Station

AGRICULTURAL DIVISION.

FEEDING LAMBS AND PIGS.



By I. P. ROBERTS

AND

GEO. C. WATSON.

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45. Tomatoes.
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FEEDING ENSILAGE TO LAMBS.

A flock of ten grade Shropshire lambs, about eight months old, was selected for this experiment and divided into two lots of five each. These lambs were thrifty, quite uniform in size and general appearance, and when divided each lot was of nearly the same total weight, and contained three wethers and two ewes.

To lot I, was given ensilage, hay, and a grain ration, consisting of one part of linseed meal, two parts cotton seed meal, and four parts wheat bran by weight. To lot II, was given hay, and the same grain ration as to lot I. The hay was mixed, mostly clover; the ensilage was made from Pride of the North corn grown in check rows and carrying a good crop of ears.

At the beginning of the experiment, December 8th, grain was fed only in the morning, but on and after December 31st grain was fed both morning and evening.

The following tables show the weights and gain of each individual lamb during the experiment, and also the totals for the whole experiment.

TABLE I.—LOT I—ENSILAGE.
Weight in pounds.

Ear mark No.	169.	174.	176.	177.	178.	Total.
Date, Dec. 8.	62.5	57.5	60.5	61.5	53.5	295.5
Jan. 5.	65	64.5	62.5	63.5	56.5	312
Feb. 11.	74	73	68.5	69.5	61.5	346.5
Mch. 28.	85.5	86	86	81	71	409.5
Apr. 27.	96	87.5	90.5	80.5	73.5	428
Gain.	33.5	30	30	19	20	132.5
Average gain per head.						26.5

TABLE II.—LOT II—DRY FOOD.
Weight in pounds.

Ear mark No.	170.	171.	172.	173.	175.	Total.
Date, Dec. 8	52.5	62	66	58	61	299.5
Jan. 5	56	65	67	62	65	315
Feb. 11	62.5	71	73.5	68.5	70	345.5
Mch. 28	72	85.5	88	79.5	79	404
Apr. 27	71	90	93.5	79	90	423.5
Gain.	18.5	28	27.5	21	29	124
Average gain per head.....						24.8

The following tables show the number of pounds of food consumed, the amount of water drank, and the total water consumed by each lot.

TABLE III.—LOT I—ENSILAGE.

	Pounds.	Dry Matter, Pounds.	Water, Pounds.
Wheat bran.....	382.6	335.3	47.3
Cotton seed meal.....	191.3	175.4	15.9
Linseed meal.....	95.6	86.8	8.8
Hay.....	606	525.3	80.7
Ensilage.....	1166	246.5	919.5
Water drank.....			2117.75
Total pounds consumed.....	2441.5	1369.3	3189.95

TABLE IV.—LOT II—DRY FOOD.

	Pounds.	Dry Matter, Pounds.	Water, Pounds.
Wheat bran	387.4	339.5	47.9
Cotton seed meal.....	193.7	177.6	16.1
Linseed meal.....	96.9	88	8.9
Hay.....	905.25	784.6	120.65
Water drank			2672.00
Total pounds consumed	1593.25	1389.8	2865.55

It will be observed from tables I and II that the gain of these two lots of lambs was very uniform, and that the total gain was

practically the same, so that any deductions we may draw from the experiment will come from comparing the cost of food consumed by the two lots, rather than any marked difference in growth or weight.

By referring to tables III and IV it is seen that the total amount of dry matter consumed by the two lots was practically the same, while the amount of water drank or consumed varies considerably. The lot fed wholly on dry food drank 555 lbs. more water during the experiment, than did the lot fed ensilage, while the total water consumed in food and drink by the ensilage fed lot was 324 lbs. more than that consumed by the lot fed wholly on dry food. By the water consumed is meant not only the water drank but the water contained in the food as well. This is found in the third column of tables III and IV.

As the grain ration fed these two lots as well as their gain was practically the same, it may be seen from tables III and IV that the ensilage seemed to take the place of a part of the hay. Lot I ate 1166 pounds of ensilage and 606 pounds of hay, Lot II ate no ensilage and 906 pounds of hay, therefore the 1166 pounds of ensilage took the place of 300 lbs. of hay or about four pounds of ensilage to one of hay. As a matter of economy the ensilage was a cheaper food than the hay in this experiment; since the cost of 1166 lbs. of ensilage is much less than the cost of 300 lbs. of hay. To carry the comparison still further, assuming as a basis a yield of two tons of hay per acre, would require as an equivalent a yield of less than eight tons of ensilage per acre. As a matter of fact our land that produces two tons of hay yields from twelve to sixteen tons of ensilage, per acre. Or the comparison may be made in still another way: if hay costs ten dollars per ton the ensilage in this experiment had a feeding value of more than two and one-half dollars per ton.

NITROGENOUS AND CARBONACEOUS RATIONS FOR LAMBS.

From a flock of twenty-seven grade Shropshire lambs, about eight months old, eighteen were selected for experimental feeding and divided into two lots of nine each. Although quite thin in flesh at the time of commencing the experiment, these lambs were thrifty and remained hearty and vigorous throughout the winter. They were sheared at the beginning of the experiment and placed in warm comfortable quarters in the University barn where the temperature seldom fell below the freezing point, even during the most severe winter weather.

The experiment was begun Nov. 15 and continued to Feb. 26. To lot I was fed hay, turnips and a grain ration of corn, 7 parts, and oats, 1 part. To lot II was fed hay, turnips and a grain ration of linseed meal, 3 parts, and wheat bran, 2 parts, for the morning feed; and for the evening feed cotton seed meal, 3 parts, and wheat bran, 2 parts.

The following tables will show the weights of the individuals at the beginning and at different periods during the experiment; also the gain for each individual and the total for the lot at the end of the experiment.

TABLE V.—LOT I—CARBONACEOUS.

Weight in pounds.

Ear Mark No.	110	113	114	96	103	104	101	95	111	Total
Weight Nov. 15.....	52	61	59	49	57	51	53	54	65	501
" " 28.....	54	64	62	50	63	53	55	59	67	527
" Dec. 23.	58	73	68	51	56	58	59	67	71	561
" Jan. 23.....	71	82	79	55	61	61	66	75	82	632
" Feb. 12.	77.5	88	85.5	54.5	65	64	71	77.5	88	671
" " 26.	85	90	90	56	66	67	74	82	93	703
Gain	33	29	31	7	9	16	21	28	28	202
Average gain per head.....	22.5									

TABLE VI.—LOT II—NITROGENOUS.

Weight in pounds.

Bar Mark No.	116	115	112	100	105	97	106	85	83	Total
Weight Nov. 15.....	62	52	62	57	48	53	54	62	53	503
" " 28.....	63	55	65	60	49	54	59	65	58	528
" Dec. 23.....	70	61.5	67	61.5	52	56	68	74	64	574
" Jan. 23.....	81	77	77	71	57	71	77	83	67	661
" Feb. 12.....	83	82.5	82	80	62.5	71	85	85	73.5	704
" " 26.....	88.5	92	86	78.5	66.5	78.5	89	91	78.5	748.5
Gain.....	26.5	40	24	21.5	18.5	25.5	35	29	25.5	245.5
Average gain per head.....	24.5									

Tables VII and VIII show the food consumed and the water drank for each lot during one hundred and three days, the time of the experiment.

TABLE VII.—LOT I—CARBONACEOUS.

Food consumed.	Lbs.	Dry Matter. Lbs.
Hay.....	982.	851.
Corn.....	831.	742.
Oats.....	119.	106.
Roots.....	1012.	80.
Water drank.....	1020.25	

The above foods gave of digestible constituents a nutritive ratio of 1 to 8.4.*

TABLE VIII.—LOT II—NITROGENOUS.

Food consumed.	Lbs.	Dry Matter. Lbs.
Hay.....	1330.	1152.
Bran.....	447.	391.
Linseed meal.....	335	305.
Cotton seed meal.....	336.	308.
Roots.....	1292.	102.
Water drank.....	2203.	

* The nutritive ratio is obtained by adding the carbohydrates, or nitrogen free extract and fiber, to $2\frac{1}{2}$ times the fat and dividing by the albuminoids or protein.

This ration gave of digestible constituents a nutritive ratio of 1 to 3.5.

It may be seen from Tables VII and VIII that the lot fed the nitrogenous or narrower ration consumed 348 lbs., or about 35 per cent., more of hay and 168 lbs., or about 17 per cent., more of grain. As each lot received all the hay and grain they would readily consume, it is apparent that the greater consumption of food and the greater increase in live weight of Lot II was due to the difference in the ration, for at the beginning the total live weight of each lot was very nearly the same, and the two lots were of the same apparent vigor and healthfulness. Not only did Lot II consume about 27 per cent. more dry substance, but the quantity of water drank was more than twice as much as that drank by Lot I.

The gain in live weight of Lot II over Lot I was about 21 per cent., and this very nearly represents the amount of dry substance consumed over that consumed by Lot I.

It will be observed from Tables V and VI that the gain of the individuals of Lot II were much more uniform than the gain of the individuals of Lot I. This condition has frequently been observed in experimental feeding at this Station, that where nitrogenous and carbonaceous rations have been compared, the gain of individuals of the nitrogenous lots has been more uniform; this may be only a coincidence and not a law, but the results of experiments already made will warrant a closer observation concerning this point in future investigations. Although the results of this experiment give no marked difference in gain of one lot over the other, the results obtained may be of value to the feeder to give some definite figures concerning the gain from the food consumed. Table IX gives a summary of foods consumed and gain in live weight obtained.

TABLE IX.

	Lot I.		Lot II.	
	Total weight.	Dry substance.	Total weight.	Dry substance.
Grain.....	950.	848.	1118.	1004.
Hay.....	982.	851.	1330.	1152.
Roots.....	1012.	80.15	1292.	102.
Total.....	2044	1788.91	3740.	2258.
Total gain.....	202.		245.5	
Pounds of grain to one pound of gain.....	4.7		4.9	
Pounds of hay to one pound of gain.....	4.7		4.6	
Pounds of dry substance to one pound of gain.....		8.8		9.2

NITROGENOUS AND CARBONACEOUS RATIONS FOR PIGS.

December 23, four Poland China pigs were selected from the University herd and divided into two lots of two each for experimental feeding, to make a test of the difference between a comparatively wide or carbonaceous ration and a narrow or nitrogenous one.

The pigs at the beginning of the experiment were quite uniform in size and individual appearance, and by referring to table XII it may be seen that the difference in weights of the two lots was less than five pounds. The pigs of these two lots were all barrows from the same breeding, and had received the same care and food until the time they were selected for this experiment.

During the entire experiment, of 125 days, 837 pounds of corn meal and 60 pounds of skim milk was fed to lot I.

580 pounds of corn meal, 300 pounds of meat scrap and 540 pounds of skim milk was fed to lot II.

Tables X and XI give the digestible constituents of the two rations, and also the nutritive ratio.

TABLE X.—LOT I—CARBONACEOUS RATION.

	Lbs. consumed.	Digestible.			
		Protein.	Nitrogen free-extract.	Fiber.	Fat.
Corn meal.....	837	72.21	507.55	12.19	57.19
Skim milk.....	60	2.58	2.52		.30

Nutritive ratio, 1 to 8.9.

TABLE XI.—LOT II—NITROGENOUS RATION.

	Lbs. consumed.	Digestible.			
		Protein.	Nitrogen free-extract.	Fiber.	Fat.
Corn meal.....	580	50.04	351.71	8.99	39.63
Meat scrap.....	300	154.58			51.19
Skim milk.....	545	23.44	22.89		2.73

Nutritive ratio, 1 to 2.8.

During the whole time of feeding there was no time when any animal did not readily consume its ration, and the gain in weight was rapid and uniform. Table XII gives the total weights of the two lots at different periods during the experiment; also the total gain and the gain per day for each lot.

TABLE XII.

	Lot 1.	Lot 2.
Dec. 23.....	123 lbs.	118.5 lbs.
Jan. 21.....	176.5 "	168 "
Mar. 7.....	281 "	257 "
Apr. 7.....	377 "	359 "
Apr. 27.....	429 "	438 "
Total gain.....	306 "	319.5 "
Gain per head per day.....	1.22 "	1.27 "



FIG. 1.—*Lot I—Carbonaceous.*



Lot II—Nitrogenous.

Since these two lots, fed on widely differing rations, had made so good a growth, about one and one-fourth pounds per day, per animal, during the entire experiment, and were so nearly alike in total weight and general appearance, it was thought best to ascertain if there was any marked difference in the composition of meat from the animals of the two lots. Accordingly a section was taken from the carcass of each hog between the eleventh and thirteenth ribs. These sections were skinned, the bone removed, and then run through a sausage cutter, thoroughly mixed and samples taken to the chemist for analysis.

Table XIII gives the results of the analysis for each sample.

TABLE XIII.

Ear mark No.	Lot 1.		Lot 2.	
	125	126	121	122
Water	23.47%	22.63%	26.17%	22.91%
Protein (lean meat) ..	7.62%	8.00%	8.37%	8.00%
Fat	67.15%	67.44%	63.43%	66.63%
Ash	1.76%	1.72%	2.03%	2.16%

It will be observed from table XIII that the difference in protein of the two lots is no greater than that in individuals of the same lot, so that in this case the wide difference in the rations of the two lots did not produce a marked difference in growth of the animals or of chemical composition of the meat,

Figure one shows a reproduction from photographs taken from a cross-section between the eleventh and twelfth ribs of one individual of each lot. These sections also show that there was no marked difference in the amount or distribution of lean and fat meat of the two animals.

Table XIV gives the weight of each animal at the close of the experiment and also the dressed weight and weight of internal organs.

TABLE XIV.

Ear mark No.	Lot 1.				Lot 2.			
	125		126		121		122	
	lbs.	oz.	lbs.	oz.	lbs.	oz.	lbs.	oz.
Live weight.....	218		211		214		224	
Wt. after bleeding..	212		207		203		217	
Wt. of blood.....	6		4		6		7	
Wt. of heart		8		6		9.5		8
Wt. of lungs.....	1	3	1	3.5	1	6	1	
Wt. of liver.....	2	14	2	13.5	4	13	4	5
Wt. of spleen....		5		3.5		4		5
Wt. of caul fat.....	1		1	1.5		10.5		—
Wt. of viscera.....	15	8	—	—	—	—	22	4
Dressed weight.....	184		—	—	—	—	180	

It will be seen that the only marked difference in the internal organs is that the livers of the nitrogenous lot were nearly twice as heavy as those of the carbonaceous lot.

The pigs fed in this experiment were of the same lot and breeding as the dams of the pigs of the succeeding experiment.

NITROGENOUS AND CARBONACEOUS RATIONS FOR PIGS. SECOND GENERATION.

Four Poland China pigs about three months old were divided into two lots of two each, November 2d, for experimental feeding to compare nitrogenous and carbonaceous rations.

In this experiment the animals of lot I were pigs of a sow fed a carbonaceous diet until the birth of the pigs; and the animals of lot II were pigs of a sow fed a nitrogenous ration. These sows were of the same breeding and received the same rations respectively as lots I and II of the previous experiment.

Some experiments of this nature have shown that a ration of clear corn meal and water did not give the desired results as a carbonaceous ration, because the animal would refuse to eat a sufficient quantity of the clear meal to give the desired gain. To avoid this difficulty a little animal nitrogen in the form of meat scrap was added to the ration of lot I or the carbonaceous lot.

This animal nitrogen was offset by adding scrap beef tallow to the ration.

The ration of lot I consisted of corn meal, 27 parts; beef tallow, 2 parts and meat scrap 1 part.

The ration of lot II consisted of corn meal, 2 parts; meat scrap, 1 part; and skim milk. The amount of skim milk fed to lot II varied somewhat from day to day, as the supply varied, so considerable water was drank by this lot during the experiment. Fresh water was constantly kept in water boxes accessible to each lot during the entire experiment.

Tables XV and XVI give the amount of food consumed by each lot, with the pounds of digestible constituents and the nutritive ratio for each lot.

TABLE XV.—LOT I—CARBONACEOUS.

	Pounds consumed.	Digestible.			
		Protein, Pounds.	Fat, Pounds.	Nitrogen-free extract, Pounds.	Fiber, Pounds.
Corn meal.....	870	67.29	26.51	535.99	6.30
Meat scrap.....	32	16.49	4.39		
Scrap tallow.....	64	.96	57.60		
Total.....	966	84.74	88.50	535.99	6.30

Nutritive ratio 1 to 9.

TABLE XVI.—LOT II—NITROGENOUS.

	Pounds consumed.	Digestible.			
		Protein, Pounds.	Fat, Pounds.	Nitrogen-free extract, Pounds.	Fiber, Pounds.
Corn meal.....	614	47.49	18.71	378.27	4.45
Meat scrap.....	307	158.19	42.09		
Skim milk.....	1758	75.59	3.52	73.84	
Total.....	2679	281.27	64.32	452.11	4.45

Nutritive ratio 1 to 2.2.

Table XVII gives the weights of the individuals of each lot at different periods during the experiment.

TABLE XVII.

Ear mark No.	Lot 1		Lot 2	
	Carbonaceous.		Nitrogenous.	
	3	4	1	2
	Pounds.	Pounds.	Pounds.	Pounds.
Wt. Nov. 2.	29.5	30.5	43.5	35
" Nov. 16.	45	38	55	43
" Dec. 21.	62	52	104	65
" Jan. 25.	87	79	139	110.5
" Feb. 12.	106.5	94.5	163.5	130
" Apr. 12.	137.5	160	219	198
Gain	167	129.5	175.5	168
Gain per day	1.18	1.07	1.45	1.85
Gain per day per lot.	2.20		2.80	

Table XVIII gives the live weight at the time of killing; the dressed weight, and the weight of internal organs.

TABLE XVIII.

Ear mark No.	Lot 1				Lot 2			
	Carbonaceous.				Nitrogenous.			
	3	4	1	2	3	4	1	2
	Lbs.	Oz.	Lbs.	Oz.	Lbs.	Oz.	Lbs.	Oz.
Wt. alive	167		160	8	219		198	
" after bleeding ..	165		157		215		192	8
" of blood	2		3	8	4		5	8
" of heart		5		5.5		10		9
" of lungs	1	6	1	9	2	1	1	7
" of liver.	2	2	2	1	3		2	13
" of spleen		2.5		2		4		4
" of stomach and intestines	9	5	10		13	7	11	12
Dressed weight	144		137		186	8	168	

The weight of the hogs dressed was taken the next morning after killing.

It will be observed from table XVII that the nitrogenous lot made a much greater growth than did the carbonaceous fed lot. The general appearance of the hogs differed even more than their difference in weight as may be seen from figure 2, which is reproduced from a photograph taken of the hogs after dressing while they were yet on the shambles. It will be noticed that the pigs of the nitrogenous fed lot were larger, longer, and showed a



FIG. 2.—Nos. 1 and 2 Nitrogenous ; Nos. 3 and 4 Carbonaceous.

less tendency to lay on fat as seen in jowls of Nos. 3 and 4. There was also a considerable difference in the proportion of lean and fat meat of the two lots as may be seen by the illustration on the title page.

The illustration marked 3 on the title page represents a cross section of pig number 3 of Lot I taken through the loin, and when compared with the illustration marked 1 taken from a similar section of pig 1 of Lot II, the relative proportion of lean and fat meat is seen to be marked. In the animal fed on carbonaceous food the amount of fat meat is not only greater but

the amount of lean meat is much less than in the animal fed on a nitrogenous ration.

In this experiment the addition of the small amount of meat scrap and scrap tallow to the ration of lot I seemed to have the desired effect of increasing the consumption of grain of that lot, for on one or two occasions when the animals of this lot were fed their usual amount of corn meal without the meat scrap and scrap tallow the meal was not all consumed, but when the same quantity of corn meal was fed with the meat scrap and scrap tallow the food was greedily consumed.

The painstaking work of Clinton D. Smith and James E. Rice, contributed largely to the success of these experiments.

SUMMARY.

1. Ensilage fed with hay to lambs gave equally as good results as where all hay had been fed, and the ensilage had the advantage of being the cheaper food. Four pounds of ensilage being equivalent to one pound of hay.

2. Lambs fed on ensilage drank less water than lambs fed wholly on dry food, but the lambs fed ensilage consumed more water in the food and the water drank than those fed dry food.

3. Where nitrogenous and carbonaceous rations were compared as food for lambs, the individuals of the lot of lambs receiving the nitrogenous ration made a more uniform gain in live weight than the lot fed a carbonaceous ration.

4. Results have not been uniform as regards the growth of pigs where carbonaceous and nitrogenous rations have been compared. In one experiment there was no marked difference in gain in live weight and no marked difference in the chemical composition of the meat. The results from another experiment showed a marked difference in the gain in live weight and also a great difference in the relative proportion of fat and lean meat.

I. P. ROBERTS,
G. C. WATSON.

Bulletin 48.

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Cornell University Agricultural Experiment Station.

HORTICULTURAL DIVISION.

**SPRAYING
APPLE ORCHARDS
IN A WET SEASON.**



By E. G. LODEMAN.

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BULLETINS OF 1892.

38. The Cultivated Native Plums and Cherries.
39. Creaming and Aerating Milk.
40. Removing Tassels from Corn.
41. On the Comparative Merits of Steam and Hot Water for Greenhouse Heating.
42. Second Report upon Electro-Horticulture.
43. Some Troubles of Winter Tomatoes.
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45. Tomatoes.
46. Mulberries.
47. Feeding Lambs and Pigs.
48. Spraying Apple Orchards in a Wet Season.
49. Sundry Investigations of the Year.

CHEMICAL DIVISION.

THE DETERMINATION OF SUGAR IN THE TOMATO.

— This determination requires some special precautions ; the possible action of the organic acids present on polarized light, precludes the use of the polariscope, and the possible action of other reducing substances than sugar on the Fehling solution is liable to render the results by this method too high.

These possibilities may perhaps account for the different results obtained by different analysts on the sugar in this fruit, although it is true that there may be wide variations in the actual proportion of sugar in different varieties.

In the Report of the Maryland Experiment Station for 1889, p. 67, are the results of the determinations of sugar in 65 varieties, the percentage ranging from 1.76 to 3.52 ; one variety gave 7.00 per cent. The determinations were made in the aqueous extract directly, with Fehling's solution, used according to the volumetric method. In the Report of this Station for 1891, from 3.89 to 5.12 per cent. of sugar is reported, as obtained by H. Snyder on eight samples ; in these determinations the extract was examined by the polariscope. Two analyses by Italian chemists gave, respectively, 1.74 and 3.7 per cent.

In the case of nearly half of the analyses made at the Maryland Experiment Station the sum of the percentages of ash, sugar and malic acid exceeds the total per cent. of dry substance ; it is thus indicated that some of these determinations of the constituents of the dry substance are too high ; and as other substances besides these three are in all probability present in this dry substance, the error is even greater than thus indicated.

Some study has been devoted to the method of determining sugar in this fruit, and the matter is still under investigation. The following is given as a preliminary report only.

It was hoped that the fermentation method could be applied ; but as results even on samples of pure glucose were unsatisfactory, its use was given up. For all the determinations reported below, the fruit was dried at 100°, the dry residue was powdered, and then extracted for the sugar by boiling water when this was the extracting agent used, or by 90 per cent. alcohol in the apparatus used in this laboratory for continuous extraction of fat by ether. The aqueous extract was so dark colored that a volumetric determination by the Fehling solution could not be made ; the alcoholic extract was much less highly colored. This solvent was used in the hope that it might extract less of other reducing substances than sugar, than water would take up. The gravimetric method, in which the copper reduced from the cuprous oxide by hydrogen was weighed, gave very satisfactory results.

The results obtained are given in the following table :

No. of sample.	Dry substance.	Sugar. Volumetric det.	Sugar. Gravimetric det.	Acid.
1	5.58	.33		.33
2	6.56	.57		.44
3	5.71	.43		.44
4	6.49	.56		.35
5	6.04	.38		.72
6	4.97		.69	1.73
7	3.89		.96	.58
8	5.72		.93	.57
9	5.70		1.01	.36
10	5.26		1.13	.34
11	6.17		1.09	.60
12	6.10		.89	.45
13	5.52		1.07	.54

The acidity was determined by means of a standard solution of potassium hydroxide, and calculated as malic acid.

It seems certain that the volumetric results were too low. The gravimetric results were obtained with the alcoholic extract ; duplicate results on the same extract agreed closely. It will be noticed that one very low result on sugar in sample 6, was accompanied by a very high per cent. of acid.

G. C. CALDWELL.

BOTANICAL DIVISION.

GOLDEN ROD WEEDS.

Complaints having been made in certain quarters in regard to the tendency of some of the Golden Rods to become more or less troublesome weeds, this note upon the subject has been prepared.

The Golden Rods constitute the genus *Solidago* of the botanist, one of the largest and most important genera of the sunflower family. They are all late summer or autumnal blooming plants, bearing clusters of small flowers, usually of a yellow or golden color. The roots are perennial, but the stems, for the most part slender or wand-like in form, are annual and herbaceous, or somewhat woody in mature plants.

About eighty species of Golden Rod are known. These vary in height from six inches or less in the Alpine variety of *Solidago virgaurea*, to eight feet or more in the large variety of *Solidago serotina*. They also differ more or less in the habit and general appearance of the plants, in the form and size of the flower clusters, in the size and texture of the leaves, and in other ways.

Nearly all the Golden Rods are attractive plants, chiefly on account of the rich, warm, golden color of the flowers. The high esteem in which they are generally held has led to a wide-spread proposal that the Golden Rod should be adopted as a national flower. Whether some particular species should be chosen, or whether any one of the eighty species might be regarded as answering all the requirements of the case, is a phase of the subject which has thus far received but little consideration.

The Golden Rods are nearly all natives of Eastern North America. Only a single species, *Solidago virgaurea*, is native to Britain and continental Europe. The number of species known to be native to the State of New York was placed at twenty-two by Dr. Torrey in 1843. Prof. Dudley admits in the Cayuga

Flora sixteen species as growing wild in the basin of Cayuga Lake. These are all found in the vicinity of Cornell University. Within one hundred miles of the city of New York twenty-five species have been recorded by the Torrey Botanical Club. In the state of New Jersey there are twenty-four species, and in the state of California only seven. In the whole of North America north of Mexico, Dr. Gray includes seventy-eight species. These figures give a general notion of the natural distribution of the Golden Rods and the relative frequency of their occurrence in different sections.

But little attention has been given to the cultivation of the Golden Rods in this country, largely owing no doubt to their abundance as wild plants. In the old world, on the other hand, where as stated only a single species is known, a considerable number are cultivated for ornamental purposes. In Nicholson's Dictionary of Gardening fifteen species are named as cultivated plants in England; but it is stated that as "they are of a coarse habit they are mostly confined to shrubberies and borders." In the botanical garden of the University all the Golden Rods native in the Cayuga Flora are cultivated by the Botanical Department for scientific purposes; and it is of interest to note that nearly all show a marked tendency to respond to the influence of cultivation in the direction of amelioration and improvement.

There is no tendency of the Golden Rods as a whole to become weeds, but a few species are regarded as intrusive and troublesome in some sections. In Halsted's check list of American Weeds ten species are included; in Darlington's American Weeds only a single species is specially named. In the state of New York, especially in the central counties and in the dairy regions, about four species have attracted attention on account of their habits as weeds. These may be named and described as follows:

1. *Solidago nemoralis*. Usually about a foot in height, the foliage of a grayish-green color. The flowers begin to appear in August—the earliest of the Golden Rods. This perhaps more than any other species has assumed a pronounced weed-like character, in certain soils and exposures over a wide extent of territory. As a weed it is common in upland pastures, especially in cold and sterile soils. In such situations it drives out grasses

and other desirable forage plants almost completely. It may be banished by subjecting the soil to hoed crops for a year or more, and by the proper use of fertilizers. In very poor soils, where this Golden Rod has secured a firm foot-hold, it is probable that the cost of eradication would exceed the value of the land for farming purposes. The intrusion of this weed into fields not already invaded should be carefully guarded against.

2. *Solidago rugosa*. Usually a larger plant than the last, but quite variable as to size. The stem is very leafy, and both stem and leaves are rough with short and stiff hairs. Like No. 1 it is capable of invading fields and pastures and driving out all desirable forms of vegetation. It is, perhaps, less likely to be found on very poor soil.

3. *Solidago canadensis*. One of the largest of the Golden Rods, the rough hairy stems often six feet in height. Old plants, after the flowers have faded, are very weed-like in aspect, but in its prime is a stately and beautiful species. Common on the borders of field and pastures, which it sometimes invades more or less abundantly. Less likely than either of the first two to overrun the soil completely, but is very persistent when once established.

4. *Solidago lanceolata*. Smaller than No. 3, the stems being usually two to three feet in height. Common especially along the banks of streams, and in moist soils, and is more or less troublesome along the borders of meadows. It also invades cultivated fields and is more likely than any other Golden Rod to become a troublesome weed in such situations, largely owing to the fact that its power of propagation by underground stems is greater than in other species.

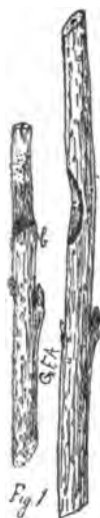
So far as is known, the different species above mentioned have nowhere received distinguishing popular names, but all are included under the general name of Golden Rod.

A. N. PRENTISS.

CRYPTOGAMIC BOTANY AND PLANT PATHOLOGY.

A NEW ANTHRACNOSE OF THE PRIVET.

A few twigs of the privet (*Ligustrum vulgare*) received from Penn Yan having the appearance of blight were communicated to me by Prof. Bailey. From 12 to 18 inches or more of the terminal

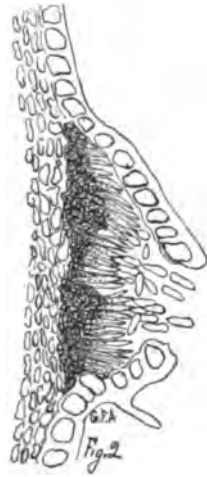


portion of some of the twigs was dead, the point where the dead portion joined the healthy presenting the depressed line observable on twigs of pear and apple affected with the blight. The resemblance to blight, however, was only superficial and confined to twigs in the final stage of the disease. Other twigs presenting an apparently healthy terminal portion were found to be diseased at a point about 12 to 18 inches from the end where a depressed area of diseased tissue was observed, oblong in outline, the longer diameter being parallel with the longitudinal axis of the stem. A comparison of the different specimens showed that this diseased area, quite small primarily, and seated only upon one side of the twig, gradually increased in size until eventually it extended entirely around the twig completely girdling it. The supply of nutriment thus being cut off from the terminal portion of the twig, death of that portion followed.

Seated in the original diseased areas, whether extending partly or entirely around the stem, are minute black elevated points which can be seen with the unaided eye. Figure 1 *a* and *b* represent portions of twigs, *a* with the diseased area extending partly around the stem, while *b* is girdled. In the diseased areas are shown these small black elevations. The disease is produced by

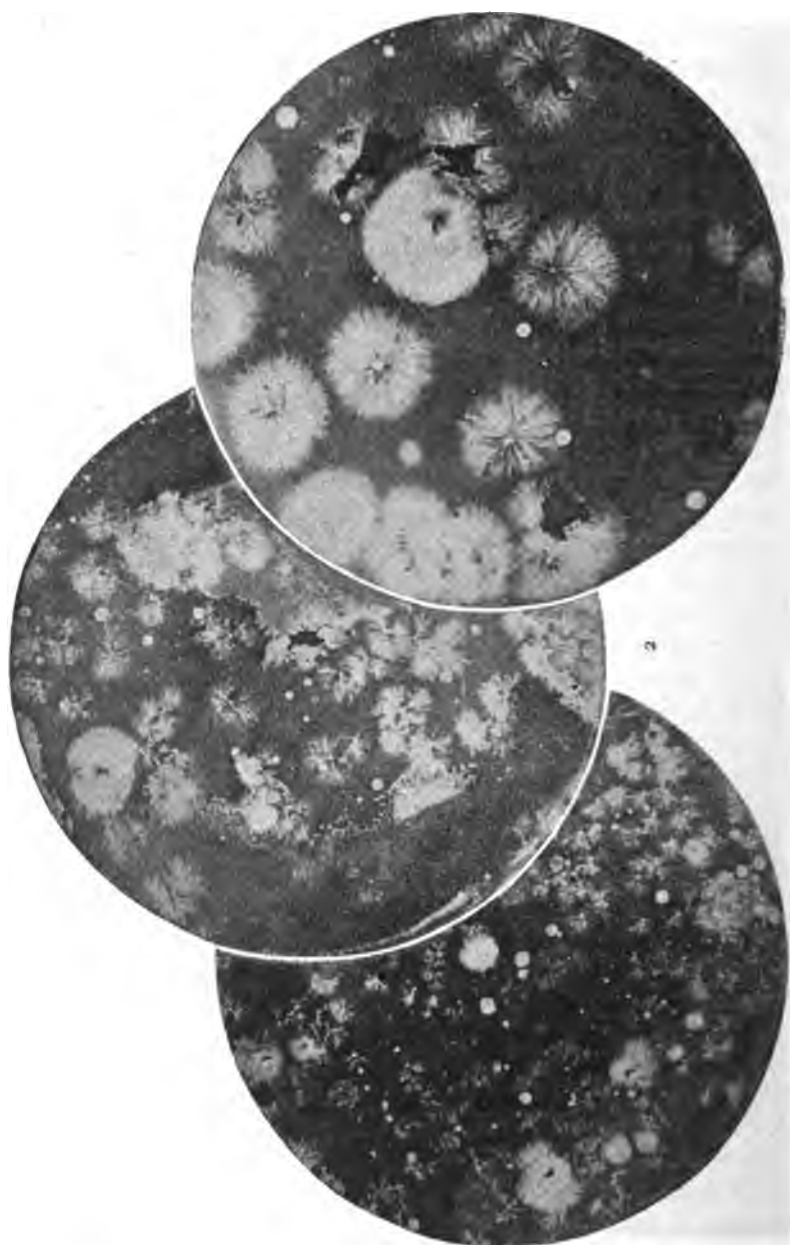
a fungus which grows within the stem. These black elevated points are centres where pustules of the fungus are developed containing its reproductive bodies, or spores.

Figure 2 represents a very thin section, across one of these pustules, magnified to show the structure of the pustule and the form of the pores. The growth of the pustule has ruptured the epidermis of the stem. In the opening between the broken parts of the epidermis are shown some of the spores. Beneath these are numerous parallel short fruiting threads, or basidia of the fungus, at the end of which the spores are developed. The basidia can be seen to arise from the blackened stroma of the fungus which consists of quite a compact association of irregular cells. The black color of the pustules comes from the stroma.



Following the analogy of other anthracnoses these spores falling upon other stems would spread the disease. The practical question is, of course, how to prevent the spread of the fungus, or the starting of the disease another year. The suggestion might be made to trim the hedge with the shears below the affected parts of twigs, and burn the trimmings. It might also be well in the spring just before the buds swell to thoroughly spray the hedge with the Bordeaux mixture to kill any spores which may have remained during the winter.

Method of separation of the fungus. To study the development of the fungus it was necessary to separate it from other common forms of fungi as well as bacteria which always find a lodgment in and upon dead plant tissue. Since all these forms are microscopic the separation involves a method of procedure familiar only to specialists, and as such beautiful results were reached in the separation of this fungus it suggested a graphic presentation of the method in connection with the study. The method used was the same as that which Koch developed so admirably for the separation of bacteria, and consists in the dilution of the organisms in several quantities of a warm liquid substance which, when



1 PLATE I. *Plate Culture, showing separation of Anthracnose.* 3

spread out in a thin layer and cooled, solidifies and holds each germ firmly fixed at one point in the dilution. This substance is usually some gelatinous base, as gelatine, or agar-agar, containing beef broth and peptone to furnish food for the organisms. In a few days after cooling the dilutions in the thin layer each germ by growth has produced a colony which can be seen with the unaided eye.

Three glass tubes containing a small quantity of liquid nutrient agar-agar were placed in a water bath at 43° centigrade. This temperature is sufficient to keep the agar liquid, while it is not hot enough to kill the organisms. Now several thin shavings through the fungus pustules on the stem of the privet were transferred to tube No. 1. This was shaken gently to distribute the germs evenly through the liquid. Now a small quantity of the liquid in No. 1 containing the germs was transferred to tube No. 2, making the second dilution, and from No. 2 to No. 3, making the third dilution. Experience enables one to judge quite accurately in making the dilutions so that we estimate the dilution sufficient to cause each germ to lie separately at different points in the liquid agar, at least in dilution No. 3.

Each of these dilutions was then poured into a Petrie dish,* and allowed to cool in a thin layer over the bottom. No germs could then be seen in the agar, since they are microscopic and lie singly. The dishes were piled away for a few days. During this time each germ grew and produced a colony which was visible to the unaided eye. The plates or dish cultures were now photographed natural size and the result is reproduced in Plate 1. In No. 3 it will be seen that nearly all of the colonies are separate. The snowflake-like colonies are those of the desired fungus. The small, compact, circular ones are those of bacteria. One large compact colony is that of a common fungus.

In Nos. 2 and 1 the fungus colonies are crowded, and have not made such good growth. The colonies of bacteria are more numerous also, and it would be very difficult to obtain a pure culture of the fungus in either of those dilutions. If the dilutions were not numbered it would be an easy thing to determine their

*A Petrie dish is composed of two shallow glass vessels, one about 14 inches in diameter which serves as the bottom, the other of a little greater diameter, which is inverted over the first one for a cover.

number from the size and number of the colonies. The very large compact colony in No. 2 is that of a motile bacterium.

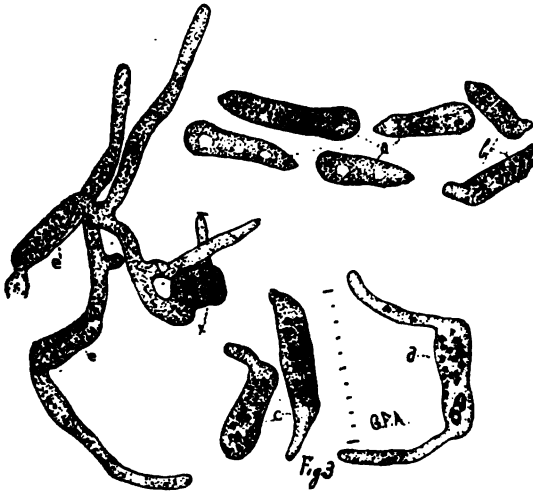
Pure cultures of the anthracnose. Pure cultures of the fungus could now be started by transplanting with a flamed platinum needle portions of the fungus colonies from No. 3 into a culture tube of nutrient agar. The photograph was taken after these transplantings were made which accounts for the broken appearance of some of the colonies.

From the point of inoculation in the culture tube, where the transplanting was made, the fungus threads grow out through the upper surface of the agar radiating in all directions. In a few days minute black bodies appear seated here and there upon the mycelium. These resemble the stroma at the base of the pustules on the stem, but in the artificial cultures do not seem to be especially concerned in the production of basidia and spores, since but a few are developed in connection with them.

Numerous basidia and spores are produced, however, all along the threads and a mass of them at the point of inoculation. In a few days more many fungus threads arise above the agar and produce a fluffy white growth upon the surface, nearly obscuring the black points.

No pigment was noticeable in these cultures. New cultures were then started by transplanting portions of agar the size of a small pea with a mat of mycelium and spores to fresh culture tubes. In the fresh agar the growth took place in the same manner as in the first tubes, but upon the surface of the transplanted portions a faint pink pigment appeared, similar to that developed in some species of *Glæosporium* and *Colletorichum*.

Cell cultures were made in order to observe with the microscope the different phases in germination of the spores and growth of the fungus. Liquid agar containing a dilution of spores from one of the culture tubes was poured upon a sterilized cover glass which was then inverted on the ring of the cell. Figure 3, a, represents some of the spores in the cell culture. They are oblong, usually pointed at one end, nearly cylindrical, and either straight or slightly curved. The appearance of the contents of the spores varies. Sometimes the protoplasm is nearly homogeneous with one or more vacuoles, or it may be finely granular, with



no vacuoles, or quite coarse granules may be irregularly distributed in the homogeneous protoplasm. The latter condition is a very common one before germination, and the behavior of these granules has suggested that possibly they may be stored products to be used during the process of germination

and the early growth of the mycelium. It does not seem there could be any need of such stored products for spores in artificial cultures where the spore lies in a rich nutrient media. But they might serve the spores a good purpose in natural conditions where the spore lies upon the surface of the plant and must often produce considerable growth of mycelium before the thread reaches nutritive tissues.

In germination one or more germ tubes arise from the spore usually at one side of the ends. Figure 3, *b* and *c* represents different stages in germination. The coarse granules are quite numerous, and in *d* some of them have moved out into the forming mycelium. Figure 3, *e* represents a farther development of mycelium and also a farther distribution of the granules in the threads.

Figure 4, *a*, *b*, and *c* are three camera lucida sketches of the growth from a spore which was sown December 14th at 12:35 P. M. *a* represents the growth which had taken place in exactly 24 hours, being sketched at 12:35 P. M., Dec. 15th. *b* was sketched from the same object at 3:15 P. M. on the same day, and *c* at 11:45 A. M., Dec. 16th. The spores are therefore developed with great rapidity under favorable circumstances. In the same culture were other spores which developed a much greater extent

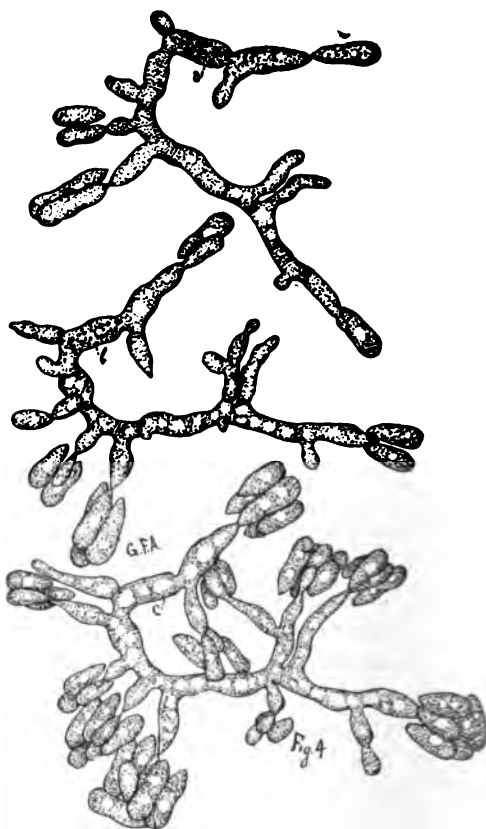
of mycelium and number of spores. This group was chosen because of its limited extent, being thus more convenient to sketch.

During the growth and production of spores the coarse granules gradually disappear. As the culture ages the mass of spores becomes greater at the center of each group of mycelium. In a few days spore production seems to cease and then long, sterile mycelial threads grow out to a considerable distance.

At the same time there are usually developed buds or gemmæ, at the ends of certain threads. These are colorless at first and may be detected by their irregularly oval outline, and greater diameter than the parent thread. They soon acquire a dark brown color, sometimes become septate, or bud into rudimentary sclerotia.

One of these developed quite early in the culture is shown at x, figure 3.

Spores were also sown on sterilized bean stems. The fungus grew readily and produced numerous spores during a few days when the threads assumed a dark brown color and grew in great profusion over the surface of the stems. Frequently the threads associated themselves into strands, or compact wefts of parallel threads several layers deep. Within these wefts and strands were developed numerous bodies suggesting pycnidia or perithecia, rotund in form, the interior cells hyaline and with rich protoplasmic contents, the peripheral cells dark brown in color.



In some cases these measured 80 to 100*, and frequently the depth of the web of dark mycelium in which they were seated exceeded this measurement.

Late upon the surface of this growth free threads arose in a procumbent, assurgent, or nearly erect position. All of this development on the bean stems took place in ten days. This culture is very suggestive of the probable development cycle of this *Glæosporium* and related forms. It probably presages the development of an ascigerous stage; whether or not that ever actually takes place is yet to be determined. The blackening of the stroma in the pustule on the stems of the privet is probably analagous to the dark web of mycelium developed over the bean stems in the culture. In this respect the fungus resembles the *Glæosporium* of ripe rot of apples.†

In the report of the Mycologist, Dept. Agr., 1887, p. 348, there is noted what seemed to be an immature pycnidial stage of *Glæosporium fructigenum*. On apples, affected with *Glæosporium fructigenum*, which were kept until mid-winter, Miss Southworth notes one conceptacle in connection with the stroma containing two asci and undeveloped spores, but the culture was so badly contaminated with other forms that it was thrown away.‡ The culture being contaminated there might be some doubt of its genetic connection with the *Glæosporium*, but all this strengthens the possibility that several anthracnoses in the future will be known as conidial stages of some more highly organized form.

The result of these cultures is to impress one with the close relationship of this *Glæosporium* on the privet to the *Glæosporium fructigenum* on apples. If it were the same species the cultivation of the privet would then bear a new and important relation, perhaps, to the spread and propagation of the ripe rot of apples. There are points of difference, however, so far as the two species are at present known, sufficient to characterize it as a hitherto undescribed species, and I propose for it the name *Glæosporium cingulatum*, or the *girdling anthracnose*.

* These measurements are in terms of the micromillimeter.

† Miss Southworth. Ripe rot of grapes and apples. Journal Mycology, Vol. vi, No. 4.

‡ Journ. Mycology, Vol. vi, No. 4.

Glæosporium cingulatum ns. p. Affected areas light brown, either oblong and on one side of the stem or later completely girdling it. Acervuli 100 to 150 in diameter, rupturing the epidermus, in age black from the dark stroma lying in the base or extending irregularly up the sides frequently forming a pseudopycnidium. Basidia numerous, crowded, simple, hyaline or when very old perhaps faintly fuliginous. Spores oblong, or elliptical straight or little curved, usually pointed at the base. From pustules on the stem they measure 10—20x5—7; in artificial cultures they are frequently much larger, but when crowded in the media, or when the nutrient substances are nearly exhausted, they may be considerably smaller—on stems of *Ligustrum vulgare*.

This is quite distinct from *Glæosporium ligustrinum* Sacc.*

NOTE ON THE CERCOSPORA OF CELERY BLIGHT.

Late in September, specimens of celery affected by "celery blight," sent by H. C. Townsend of Wappinger's Falls, Dutchess Co., were communicated to me by Mr. Turner of the New York Weather Service. The disease was determined as due to the fungus *Cercospora Apii* Fres. A short note on the disease was then published in the Crop Bulletin of the New York Weather Service, for the week ending Sept. 24, 1892. It has long been known in Europe and has been recorded several times in various parts of the United States during the past several years. It sometimes occasions quite serious injury to the celery crop, in some cases materially lessening the product and also rendering the diseased plants less desirable for market.

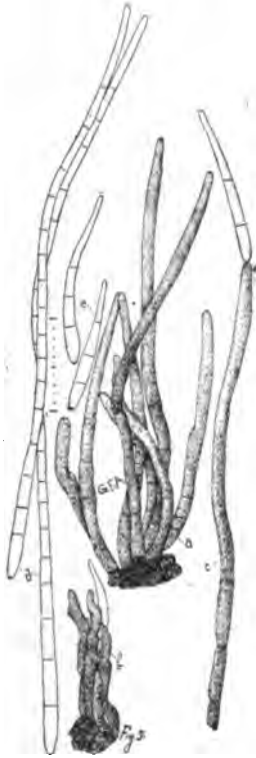
Halsted of the New Jersey Experiment Station shows that the disease can be held in check by the use of the standard carbonate of copper and ammonia mixture applied with a knapsack sprayer.‡

The object of this note is chiefly to call attention to some confusion which exists concerning certain morphological characters

*Sylloge Fungorum, Vol. iii, p. 704.

‡Twelfth Annual Report N. J. Agr. Expt. Station, 1891.

of the fungus. Like all *Cercospora* the vegetive threads of the fungus usually grow largely in the interior of the leaf and when the nutriment at the affected spot is nearly exhausted, clusters of fruiting threads arise from the vegetive ones, and issuing from a stoma of the leaf bear elongated spores at their ends. Two clusters of the fruiting threads of *Cercospora Apii* are shown at *a* and *b* in figure 5, while *c* represents a single fruiting thread with a spore still attached, and free spores are shown at *d* and *e*.



The fungus was first described by Fresenius.* The description given by Saccardo† represents the form developed under normal conditions, the hyphæ measuring 40-60x4-5 and the spores, or conidia, 50-80x4. The form of the conidia is given as obclavate, *i. e.*, the base or end at the point of attachment with the hyphæ is greater in diameter than the distal extremity. The conidium *in situ* at the end of the hypha, figure 5, *c*, shows this character well. It was also observed in numerous other cases. Furthermore the free or abjoined conidia nearly always present a well defined scar at the larger end as shown in *d* and *e* figure 5. This scar indicates the place of attachment to the hypha, the corresponding scar on the hypha being at the end or at one of the geniculations as shown in *a* and *b* figure 5. The explanation of several scars appearing on a single hypha is that after a conidium is abjoined from the end, the hypha then grows out at one side of the scar and bears another conidium at the end, and so on. These scars at the base of the conidia enable one to determine their form even when they are not attached to their parent hyphæ.

*Beiträge zur Mykologie, Frankfurt, 1850-1860.

†Sylloge Fungorum, Vol. IV, p. 442.

In the report of the Mycological Section* for 1886 is a short note on the distribution of this fungus in the United States. The form of the conidia is not given in the text, but they seem to be inverted in the illustration where they are shown to be attached by their small ends to the hyphæ. Figuring them thus is equivalent to calling them clavate with reference to their relation to the hyphæ which is contrary to the original descriptions and also to fact.

In the report of the New Jersey Station for 1891 (l. c.) the conidia are described as club-shaped. No figure is given and we infer that the writer used the term "club-shaped" without any reference to their relation to the hyphæ.

Under normal conditions the fungus is confined to well defined spots on the leaf with an irregular, slightly raised border. During excessively wet weather, as the leaf tissue is dying, it may spread to portions of the leaf where the spots are not so well defined. Such conditions also induce a much longer growth of the tufts of hyphæ and their conidia. Figure 5 *a* and *d* represent such forms in comparison with *b* and *c* developed under normal conditions. The measurements including such variations are as follows: Hyphæ 50-150x4-5; conidia 50-280x4-5. The figures are all drawn to the same scale, using compensation ocular No. 6 and objective 4mm, Zeiss, with aid of camera lucida. The micrometer scale of this combination is also projected by the side of the figure.

GEO. F. ATKINSON.

*Report, Department of Agriculture.

† All the figures where the scale is shown are drawn with the same combination, the objects being magnified 30 times more than the scale.

AGRICULTURAL DIVISION.

CORN—DETASSELING EXPERIMENT.

July 20th, 1892, a portion of the University corn field was selected for an experiment in testing the effect on corn production, of removing the tassels as soon as they appeared. This portion consisted of 44 rows of corn with 27 hills in each row. This plot was surrounded on all sides by corn of the general corn field, was of the same variety of corn, Pride of the North, and received the same cultivation as the rest of the field.

The tassels were removed on alternate rows for the first 20 rows and on three-fourths of the rows of the remaining 24 rows. That is, the tassels were removed from three rows and left on the fourth; removed from the next three and left on the fourth, and so on throughout the 24 rows. The tassels were removed as soon as they could be seen, and before they had expanded. The operation was performed by hand by giving the tassel an upward pull which caused the stalk to break off above the upper joint without injuring the leaves at all.

From the three experiments made at this station in detasseling corn it has been observed that it is of the *utmost importance to have the tassels removed at the earliest time possible*, certainly before they have become expanded, and still better if enclosed within the folds of the leaf. These tassels may be readily removed by pulling as described above when enclosed in the leaf, if only the very tip of the tassel be exposed to view. And further, it is essential that the tassels be removed in such a manner that the leaves are not in any way injured, which would be the case were they removed *at the proper time* by a corn knife.

The following tables give the number of stalks, the abortive, good and poor ears, the weight of stalks, and the weight of good and poor ears for each row.

TABLE I.

	Num- ber of stalks.	Number of ears.			Weight of ears.		Weight of stalks.
		Abor- tive.	Good.	Poor.	Good.	Poor.	
Row 1, Tassels removed...	128	40	70	53	32.5	11.	70.
" 2, " left on.....	128	44	60	48	30.	9.	80.
" 3, " removed..	133	47	69	54	33.5	12.5	76.5
" 4, " left on.....	122	30	52	49	27.	8.5	76.5
" 5, " removed..	129	47	62	56	32.	13.	75.
" 6, " left on....	121	38	62	40	30.5	10.	77.5
" 7, " removed..	129	47	70	50	35.	11.5	76.
" 8, " left on.....	130	29	55	47	28.5	11.	76.
" 9, " removed..	117	30	60	50	30.5	13.5	66.
" 10, " left on....	130	29	55	53	28.5	12.	82.
" 11, " removed..	120	51	73	39	37.	11.5	75.5
" 12, " left on....	116	35	52	40	27.	9.	74.5
" 13, " removed..	122	39	57	34	36.	8.	70.5
" 14, " left on.....	120	29	63	44	32.5	11.	77.
" 15, " removed..	133	36	72	44	36.5	12.	77.
" 16, " left on....	127	29	75	27	39.	5.	83.
" 17, " removed..	125	23	77	49	38.	12.5	76.5
" 18, " left on.....	114	35	58	37	30.	7.5	79.5
" 19, " removed..	114	25	60	49	29.5	13.	70.
" 20, " left on....	107	20	40	47	26.	10.	70.5
Average Tassels left on	122	32	57	43	30.	9.	78.
" " removed ..	125	39	67	48	34.	12.	73.

Gain in weight of good ears, 13 per cent.

Gain in weight of poor ears, 33 per cent.

It will be observed that these results show a gain in numbers of good and poor ears, also in their weight. An average increase of 15 per cent. of good ears and 26 per cent. of poor ears by weight.

In this experiment all short and poorly formed ears were counted as poor ears, although the corn was practically all sound. All sets producing silk without grain were counted as abortive ears.

As the experiment of removing tassels from corn has been made at several experiment stations with varying results, a general summary of the results to date may be of value in drawing conclusions on the effect of the practice. The results of the various experiments made at different experiment stations may be summed up as follows :

TABLE II.

	Number of stalks.	Abor- tive.	Number of ears.		Weight of ears		Weight of stalks.
			Good.	Poor.	Good.	Poor	
Row 21, Tassels removed..	125	43	70	47	35.	14.5	77.5
" 22, " " "	105	22	64	40	32.5	11.	74.
" 23, " " "	116	30	72	41	35.5	10.	70.5
" 24, " left on....	121	36	62	42	32.	9.	79.
" 25, " removed ..	110	54	72	31	38.	7.5	78.
" 26, " " "	127	22	72	40	36.5	9.5	71.5
" 27, " " "	129	35	69	46	36.	11.	72.5
" 28, " left on....	133	36	50	50	26.	11.5	78.
" 29, " removed ..	126	29	63	56	31.	13.5	70.
" 30, " " "	120	44	61	53	32.5	13.	75.
" 31, " " "	111	38	61	46	32.	11.5	67.5
" 32, " left on....	129	32	60	46	30.5	9.	65.5
" 33, " removed ..	118	33	52	58	27.	14.	67.5
" 34, " " "	110	35	62	41	32.	12.	66.5
" 35, " " "	109	30	66	46	34.	13.5	65.
" 36, " left on....	130	33	55	37	27.	9.	68.5
" 37, " removed ..	120	36	60	56	32.	14.	71.
" 38, " " "	124	37	69	48	36.	11	73.5
" 39, " " "	115	25	70	54	37.5	13.	74.5
" 40, " left on....	136	29	60	47	31.5	10.	80.5
" 41, " removed ..	114	34	60	54	35.	16.	78.5
" 42, " " "	128	30	74	49	39.	12	80.5
" 43, " " "	124	26	78	38	39.	9.	78.
" 44, " left on....	123	36	54	46	28.5	11.	86.5
Average Tassels left on... ..	129	34	57	45	29	10	76
Average Tassels removed...	118	34	66	46	34	12	73

Gain in weight of good ears, 18 per cent.

Gain in weight of poor ears, 20 per cent.

Nebraska—Two experiments; tassels removed by a corn knife; results decidedly unfavorable.

Kansas—A gain in favor of removing the tassels.

Maryland—Slightly decreased yield.

Of three experiments at this station, two give an increase in yield of 50 per cent. and 17 per cent. respectively, while the third shows no change in yield.

It will be noticed that of the total number of experiments, about one-half have received a marked increase in the yield of corn and about one-half report a decrease, but from the experi-

ments made in removing the tassels as soon as they could be seen and without injuring the leaves, the results show, as an average, a *marked* increase in the yield of grain.

The varying results of these experiments tend to show that there are some conditions not well understood, that have a marked influence on the result of this practice, and that it is worthy of more extended investigation.

GEORGE C. WATSON.

EFFECT OF FERTILIZERS ON TOBACCO.

In the spring of 1892, four plots were selected to make a test of different kinds of fertilizers on tobacco. This test was made as a preliminary trial to future experiments and intended only as a guide for investigations in testing different kinds and qualities of fertilizers when applied to the tobacco crop. As these results were quite marked, the publication of a brief account of the experiment seemed to be warranted from the data obtained.

Of the available land for this experiment four adjoining plots of $\frac{1}{4}$ acre each were selected. The soil was a heavy clay loam quite poor in plant food, and not very uniform. Although the plots were only four rods long, the soil varied considerably from one end of the plots to the other. These plots were situated on a western slope; the east or upper ends of each plot was more clayey and the west or lower ends more loamy. This variation in the soil was quite uniform throughout all the plots, that is the soil in one plot varied about as much as it did in another.

April 15th, a load of 2355 lbs. of barn manure was spread on plot one. April 18th all plots were plowed.

June 21st, plots 1, 2 and 3 were set to Zimmer Spanish tobacco, setting five rows to each plot and forty plants to the row.

June 24th, plot 4 was set to Spanish Zimmer tobacco, with plants like those set on the other plots.

A commercial fertilizer containing nitrogen, phosphoric acid and potash was applied to plots 2 and 3 on the following dates: July 1, July 14, August 6.

The potash applied to plot 4 was in the form of a high grade sulphate (90 per cent. pure), while the potash applied to plot 3 was in the form of a chloride (muriate) 80 per cent. pure.

4.8 lbs. of potash, 3.16 lbs. nitrogen, and 3.20 lbs. of phosphoric acid was applied to each of plots 2 and 3. The nitrogen was in the form of nitrate of soda, guaranteed 96 per cent. pure. The phosphoric acid was in the form of available fine rock phosphate.

The fertilizers were sprinkled around the plants and hoed in. Plot 4 received no fertilizer whatever, but received the same cultivation as plots 1, 2 and 3. September 17th, the tobacco on all plots was cut and weighed, the weighing being done immediately after cutting.

The following plan of the plots will show the amount of fertilizer applied to each plot and the weight of tobacco at the time of cutting. This plan shows the relative location and size of the plots, with the kind and amount of fertilizer applied, and also the yield of tobacco.

EAST.

PLOT 1.	PLOT 2.	PLOT 3.	PLOT 4.
Barn manure, 2355 lbs.	Sulphate of potash, 10 lbs.	Chloride of potash, 10 lbs.	No fertilizer.
	Nitrate of soda, 20 lbs.	Nitrate of soda, 20 lbs.	
	Plain super phos- phate, 20 lbs.	Plain super phos- phate, 20 lbs.	
Weight of tobac- co, 517 lbs.	Weight of tobacco, 457 lbs.	Weight of tobacco, 442 lbs.	Weight of tobac- co, 236 lbs.

WEST.

From the foregoing plan of the plots it will be observed that the barn manure plot produced the most tobacco, but if the cost of the fertilizers of all the plots are taken into account it will be seen that the commercial fertilizer may be favorably compared to the barn manure, and that the commercial fertilizer produced about twice the weight of tobacco as did the adjoining plot which received no fertilizer.

Although the plots receiving the commercial fertilizer received the same number of pounds each of plant food, the slight difference in yield in tobacco cannot safely be attributed to the difference in the quality of the potash applied without being corroborated by other trials.

While the yield of tobacco from the plot treated with barn manure was somewhat greater than the yield from the plots treated with commercial fertilizers, it is not at all certain that more tobacco was grown for the plant food supplied on the manured plot, than on the plots treated with commercial fertilizer.

GEORGE C. WATSON.

RESIDUARY EFFECT OF A GRAIN RATION FOR COWS AT PASTURE.

During the summer of 1891, an experiment was made in feeding grain to a herd of milch cows at pasture. In selecting this herd the aim had been to secure a herd where the practice had not been to feed grain while at pasture, and where the conditions as regards the pasture and the care of the animals would fairly represent a large proportion of the farm dairies of the state. Such a herd was found at McGrawville, the property of C. M. and W. L. Bean, and placed at the disposal of the officers of this station in conducting this experiment, which lasted from May 22 to October 23.

The results of this experiment were published in detail in Bulletin 36, December, 1891, and may be briefly stated as follows :

A herd of 16 cows, thoroughbred and grade Jerseys, was divided into two lots of eight each. Lot I, received

2600 lbs of corn meal.
 1300 " cotton seed meal.
 1300 " bran.

Total 5200 lbs of grain.

Lot II received no grain.

Lot I gave 22628.5 lbs. of milk.

Lot II gave 17697.75 lbs. of milk.

Or 4930.75 lbs. of milk more for the grain fed lot, a gain of about $3\frac{1}{2}$ lbs. per cow per day. The cows of this herd were quite thin in flesh, but made a good gain in live weight during the experiment. The grain-fed lot gained 166 lbs. per cow and the lot receiving no grain gained 113 lbs. or a gain of 53 lbs. per cow in favor of the grain-fed lot. Since the grain-fed lot had given about 27 per cent. more milk and had gained 53 lbs. in live weight per cow more than the lot receiving no grain, the question then arose whether this increased milk flow and the gain in live weight of lot I over lot II would have any influence on the flow of milk the following year. Accordingly the weight of milk produced by each cow that still remained in the herd was recorded for six months, beginning April 1, 1892.

The following table shows the weight of milk per cow, per month, for each lot, and the difference in favor of the grain-fed lot of the cows still remaining, or six cows in each lot :

	Lot 1.	Lot 2.	Difference.
April.....	473.8	354.8	119.
May	619.7	540.2	79.5
June.....	750.8	646.3	104.5
July	683.5	570.1	113.4
August.....	535.7	499.9	35.8
Sept.....	376.4	348.4	28.
			480.2

A gain of 16.2 per cent. in yield of milk.

From this table it may be seen that for six months, beginning with April of the season following that which the grain was fed, the lot which received the grain gave 480.2 lbs. of milk per cow more than did the lot receiving no grain. This gain represents an increase of a trifle more than 16 per cent. in favor of the grain

fed lot. It seems reasonable to assume that this increased production was due to the grain fed the preceding year, especially in the case of the younger animals. Indeed it was plainly evident that the grain fed two year olds and three year olds developed into better animals than their stable mates having no grain.

I. P. ROBERTS.

ENTOMOLOGICAL DIVISION.

THE BLACK PEACH APHIS.

Aphis persica-niger.

Order *Hemiptera* ; family *Aphididæ*.

A small brownish-black plant-louse often appearing in great numbers upon the leaves, twigs, and roots of young peach trees, frequently dwarfing and often causing the death of the tree.

The object of this article is to call the attention of peach growers to the fact that a very serious insect pest is being introduced into our state upon nursery stock purchased in other states. A correspondent in Niagara County has introduced the pest into his orchard of twenty acres by filling in the places where trees had died with infested trees received last spring from a nursery in Delaware. A few infested trees which were left over were trenched near some pits just planted ; the pest soon found its way to the young seedlings, and by midsummer nearly every seedling had succumbed to the attacks of the aphids. So far as we know this is the first instance of the occurrence of this insect in our state, but probably other growers have suffered previously more or less in other localities without knowing the cause.

The insect is very common throughout the whole of the great peach growing districts of New Jersey, Delaware, Maryland and Virginia. Growers there say it is more to be dreaded than the borer (*Sannina exitiosa*), and in destructiveness it ranks next to the fearful mysterious disease of Peach Yellows. Trees less than three years old suffer the most. In 1890, nearly 100,000 in a single nursery in one of these states were killed in two or three weeks' time, while many other large nurseries were either entirely destroyed or very badly affected, and many orchardists were compelled to replant hundreds of trees. Nurserymen, and those who are starting peach orchards, can thus see what fearful havoc may result if this pest is once introduced among their trees.

Indications of the presence of the pest.—As the pest often confines its attacks almost entirely to the roots of the trees, its deadly work frequently appears when there is nothing to indicate the existence of an insect as its cause. A stunting or dwarfing of the young trees is one of the most marked symptoms of the presence of the pest. Sometimes three or four year old trees are but little larger than when first set. The foliage of such trees presents a yellowish-green sickly appearance. Rarely a tree after languishing a year or two recovers and makes a good tree. Under favorable conditions the insect may appear in great numbers on the tree above ground and its growth be nipped while yet in the bud; the growing shoots dry up and the young tree soon dies.

Its past History.—This insect has been known to the peach growers of the Atlantic States for more than a quarter of a century. From 1860 to 1875 it was particularly destructive to Maryland. In 1874 it is first recorded as appearing above ground in destructive numbers. While investigating the Peach Yellows in 1887, Mr. E. F. Smith came across the insects upon the roots of the trees; and as the Yellows had by some been attributed to this aphid, Mr. Smith made many observations on the pest from which we get most of our knowledge of its life history and habits. The severe outbreak of 1890 has already been noted. Two or three years ago the pest was carried into the Michigan peach district on nursery stock from the east. It seems not to have gained a foothold among the California orchards as yet; the Board of Horticulture of that state is fully alive to the importance of the pest, and it is on the alert to prevent its introduction.

Its classification.—This insect is one of the true bugs belonging to the same family—the *Aphididae*—as the Grape Phylloxera, the Grain Aphid, the Hop Louse, and many other well known plant-lice pests. Scientifically the insect is known as *Aphis persicae niger*—the Latinized form of the common name, Black Peach Aphid. This name was given it in 1890, by Mr. E. F. Smith, who after comparing it with descriptions of allied known species became convinced that the species was new and so described it. Mr. Smith believes that the insect is a native species, as he found it common on the roots and branches of the wild plum, *Prunus chicasa*, thus indicating that this may be its original food plant.

The appearance of the insect.—The pest appears in two forms,

the more common form without wings (Fig. 1), and a form occurring in limited numbers provided with four ample wings (Fig. 2). The adult wingless insect is a little less than one-tenth of an inch in length and of a dark shining brownish-black color with portions of the legs yellowish.¹ Figure 1 shows the shape and general appearance of the wingless form; the hair line at the right represents the natural length of the body. Two very short tubercles



FIG. 1.—*Wingless viviparous female.*

called honey-tubes project from the caudal end of the abdomen. The beak lies along the breast of the insect when at rests but when feeding it is placed against the leaf at right angles to the body, and four fine bristles moving in a groove of the beak are forced into the tissues and the sap is pumped through this apparatus into the body.

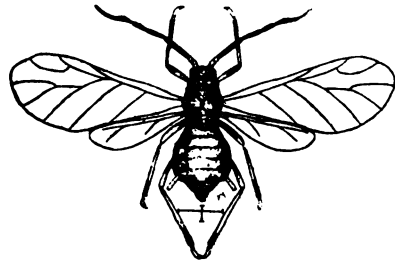


FIG. 2.—*Winged viviparous female.* (After J. B. Smith).

The adult winged forms have the long transparent wings carried roof-like over the sides of the body when at rest. These forms also differ from the wingless ones in being slightly longer and more slender, and in having longer antennæ and honey-tubes, as is shown in figure 2; the lines beneath the figure represent the natural size of this form.

In its younger stages the insect resembles the adult, but is lighter in color. All the forms thus far observed are females; often plant-lice breed freely for many generations or even years without the appearance of males, nothing but the agamic females being produced.

The life history of the insect:—Plant-lice present more varied, peculiar, and interesting phases in their life histories than do most other insects. The mother is often viviparous, that is she brings forth her young alive; the little louse may be seen kicking to free itself from the mother who is perhaps calmly walking about or

feeding. Many generations of these agamic females may be produced in succession, and it requires only eight or ten days for a generation. And further, as one mother may give birth to one hundred young at the rate of four or five a day it is easy to see with what astonishing rapidity these insects may often multiply.

The Black Peach Aphis breeds thus agamically all the year round, and no eggs nor males have been found. Only the wingless forms occur upon the roots where they breed freely and are to be found at all seasons of the year, often a foot or more beneath the surface even in stiff clay soils ; sandy soils are however preferred by the pest.

Early in spring as soon as the buds begin to swell, some of these root forms make their way to the surface and to the branches. Here the winged form develops and flying to new quarters founds other colonies, thus spreading the pest. These branch forms are the most numerous from April to July. About midsummer most of these make their way to the ground and to the roots. Usually a few specimens remain on the leaves throughout the summer and autumn and even through the winter. Our correspondent in Niagara County wrote us November 24th, that although it had frozen hard twice, the aphids were as lively as ever on the branches. These individuals which thus hibernate upon the branches with those which come from the ground form the nucleus for the early spring broods.

This pest is often accompanied by a small yellow ant which has been seen transporting the aphids to places of safety. It is believed that the distribution of the root forms is thus facilitated by the ants, and they may also aid in getting the aphids to the surface in the spring. The aphids repay the ants for their assistance by secreting a sweet liquid called honey dew upon which the ants feed.

The root forms mostly congregate on the tenderest roots, but some are to be found on all parts of the root system. Many of them still cling to the roots when the trees are dug up, and they are thus often transported great distances on nursery stock. The pest then readily acclimates itself to its new home and soon spreads throughout whole nurseries or orchards.

Above ground the insects attack the swelling buds in the spring, and later their increase in numbers crowd them onto the

twigs and leaves. As each little aphid begins to suck the sap as soon as it leaves the body of the mother, the result of so many hundreds of these little pumps working almost continuously upon both roots and branches must be a speedy check to the growth of the tree.

Methods of preventing the ravages and spread of this pest:—If this pest once gets a good foothold in a nursery or young orchard, it will prove a difficult insect to fight. Those individuals that infest the branches are easily reached and have been found to succumb readily to either Kerosene Emulsion or a strong Decoction of Tobacco.* The emulsion should be diluted with nine or ten parts of rain water, the 3 gallons of the formula thus making about 30 gallons to be used in spraying. This diluted emulsion will probably prove the most effective, although the tobacco has been used with equal success in some instances. Care should be taken in the preparation of either insecticide; many of the reported poor results from the use of insecticides is due to their not being properly prepared and used.

As it is the young trees which usually suffer, either insecticide can be easily applied with a knapsack sprayer or small force pump. Apply in as fine a spray as possible and drench the trees. In rare cases a second application a few days later may be necessary. The best time to spray is in April or May when the branch forms are the most numerous.

The root forms will not be reached by this method, hence the

*To make the emulsion, thoroughly dissolve $\frac{1}{2}$ pound hard or soft soap in 1 gallon boiling water. While this solution is still very hot, add 2 gallons kerosene and quickly begin to agitate the whole mass through a syringe or force pump, drawing the liquid into the pump, and forcing it back into the dish. Continue this for five minutes or until the whole mass assumes a creamy color and consistency which will adhere to the sides of the vessel, and not glide off like oil. It may now be readily diluted with cold rain water, or the whole mass be allowed to cool when it has a semi-solid form, not unlike lopped milk. This stock, if covered and placed in a cool dark place will keep for a long time. In making a dilution from this cold emulsion, it is necessary to dissolve the amount required in three or four parts of boiling water, after which cold rain water may be added in the required quantities.

The tobacco decoction is made by steeping 5 pounds of tobacco stems in 3 gallons of water for 3 hours; then strain and dilute with enough water to make 7 gallons. The decoction is now ready for spraying without further dilution.

relief obtained in this way is only partial. There is on record no experiments in the destruction of this form and we have had no opportunity to make any, but we suggest the use of very liberal quantities of the diluted kerosene emulsion on the surface of the soil over the roots just before or during a rain. This suggestion is based on the results of experiments with a species of White Grub, the larva of *Allorhina nitida*, an insect closely related to the common May Beetles of the genus *Lachnosterna*. The lawns about the Capitol at Washington being badly infested by these White Grubs in 1888, afforded an opportunity to try the effects of a dilute kerosene emulsion applied upon the surface. After applying the emulsion the lawns were thoroughly drenched with water to help carry the oil into the soil. The result was very satisfactory; after a few days the Grubs appeared sick, and a month later no live ones could be found.

If the aphids on the roots of the trees can not be reached by an application of the emulsion as described above, the trees should be removed at once, burned, and the ground left unoccupied for several months or used for other purposes. The insect could thus be starved out as it is not known to feed upon any other cultivated plants except rarely the plum.

In the discussion thus far of preventive measures it has been supposed that the pest has already gained a foothold in the nursery or orchard. However, to many peach growers in the state the pest is as yet unknown, and they will desire to know how they can prevent its gaining a foothold among their trees. Growers who raise all their own trees from pits will not be troubled with the pest unless careless neighbors introduce it on stocks purchased in infested regions.

If it seems necessary to purchase nursery stock elsewhere, and especially in regions known to be infested, it should be quarantined and very thoroughly treated with an insecticide immediately upon its arrival. Dip each tree in either the diluted kerosene emulsion or the tobacco decoction made as described above for use against the branch forms. As the insecticide acts very quickly, the tree need remain in it but two or three minutes. This method it is believed will effectually destroy all aphids that may be on the trees.

Another method which would doubtless be equally effective is

the one used largely in California where the law requires that all trees, plants, cuttings, grafts, buds, seeds, pits, or scions coming into the state shall be disinfected upon arrival. The disinfection is done by fumigating the trees, etc., with hydrocyanic acid gas, a deadly poison. In fumigating, the trees, etc., are placed in an air-tight tent or box, and for each 100 cubic feet of space in the box or tent one ounce of fused cyanide of potassium (58 per cent.), one fluid ounce of sulphuric acid, and two fluid ounces of water are used. The cyanide of potassium is placed in an earthenware vessel, the water poured over it, the sulphuric acid then added, and the box or tent closed tightly immediately and kept closed for at least forty minutes.

Every peach grower should take sufficient interest in the welfare of his own orchard and that of his neighbor to treat in one of the above ways all peach stocks purchased in localities where the pest is known to be present, as in New Jersey, Delaware, Maryland, or Virginia. If this be thoroughly done our peach orchards will have one less serious insect foe to fear. And the growing nursery industry of New York State, which now has nearly 500 acres devoted to peaches, constituting nearly 15 per cent. of all the peach stocks grown in the United States, will not suffer as it would were it known that this pest is liable to accompany the trees sent out.

MARK VERNON SLINGERLAND.



The New Maize (*Zea canina*). Detail of a portion of an ear, full size.

HORTICULTURAL DIVISION.

A NEW MAIZE AND ITS BEHAVIOR UNDER CULTIVATION.

In 1888 the late Sereno Watson of Harvard University received from Professor A. Dugès of Guanajuato, Mexico, some stalks and kernels of a wild corn which was found at Moro Leon about four Mexican leagues north of Lake Cuitzco, near the southern boundary of the State of Guanajuato, in Southern Mexico. The corn was wholly unknown to cultivation, and the natives of the district believe it to be the original source of the cultivated varieties of maize. This opinion is of great interest because the original form of Indian corn is wholly unknown. It is known among the natives as *mâis de coyote*, from the resemblance of the little kernels to dog's teeth. About a half dozen ears, in a cluster, were with the specimens sent to Harvard, each ear about two inches long and bearing a few rows of very small pointed white kernels. The ears and kernels were peculiar in themselves, but the fact that they were borne in clusters attracted close attention. Mr. Watson gave me two or three kernels of this corn, which I planted in a forcing-house in the spring of 1889. One seed germinated, and the plant grew well until it reached a height of three feet, when it was destroyed by an accident. This was probably the first attempt to cultivate this corn. In 1890, it was grown in the Botanic Gardens at Cambridge, having been started under glass. "The season was a long one," Mr. Watson writes, "and there was no heavy frost in Cambridge until near the end of October. The corn, however, was at that time still very green, and the stalks were finally cut and stored under shelter in the hope that the ears would ripen in the stack; but upon very few did any of the kernels mature." The tallest stalks were over ten feet high, with a diameter of nearly two inches. But the most striking peculiarity of the plants was the

abundance of lusty suckers which "grew as rapidly as the main stalk, so that the plants, which had fortunately been placed some feet apart, had the appearance of two 'hills,' one of the two having nine and the other twelve stalks ascending from a common base." The central stalk also branched higher up on its trunk, and these side branches, as also those from the base of the plants, had a tassel upon the end and bore several ears along their length!

The tassel was very large, with drooping branches. Mr. Watson showed me these plants late in the summer of 1890, with much enthusiasm; and it was easy to see that in the robust habit and multiple ears of the plant there were possibilities for the breeding of a new type of corn.

Mr. Watson concluded that this corn is a new and distinct species, rather than the original of the common corn, and he therefore published it* as *Zea canina*, or dog-tooth corn, thus adding a second species to the genus *Zea*.

In 1891, I grew the corn again from the original Mexican samples—which Mr. Watson divided with me—starting it late under glass (May 22), and setting it out of doors June 12, in a heavy clay loam, when about half a foot high. The plants grew vigorously, and ears began to form late in summer, being borne upon strong lateral branches as before. The illustration on page 332 shows a typical plant. It will be seen that six arms or branches spring from the main stalk. A dozen or fifteen ears set upon these arms. The detail drawing in the upper corner shows nearly half of an average ear, full size. These plants appeared to differ from those which I saw at the Harvard Botanic Garden the year before only in smaller size and earliness. The smaller size may have been due to the soil, which was poorer than at Harvard, but I thought I saw a decided tendency towards acclimatization in the plants, and this is now apparently warranted by the results of this year's experiment. Some of the plants did not make lateral arms, but simply sent up a straight almost earless stalk. Perhaps this was due to the fact that the plants were crowded. Some of the plants matured several good ears.

Experiments must now be tried with hybridizations. A cross with the common field corn or sweet corn would perhaps be too

*Proc. Amer. Acad. Arts and Sci. xxvi. 158.

violent. On September 17, 1891, cross-pollinations were made from sweet corn, however, the variety sold as Extra Early Marblehead Sugar. But some less violent cross must be attempted, and another male parent was chosen from the Japanese Striped corn, which is a type grown for ornament and in which the ears and kernels are small. This corn is known in the trade as "*Zea Japonica*." The leaves are striped lengthwise with broad lines of white. The kernels are rounded and yellowish, and the ears are four or five inches long. On September 21 pollen from this Japanese corn was applied to the *Zea canina*, and 17 seeds resulted from this union. From the pollination with the Marblehead Sugar, however, only three kernels were procured, and all were small and weak, and it was doubtful if they would grow.

These seeds were saved with the greatest care and curiosity. They were all sown under glass April 14, 1892. From the 17 Canina $\times$ Japanese seeds, 14 good plants grew, while from the three Canina $\times$ Marblehead seeds, only one grew. All the plants were set near each other in June in heavy clay loam. A few plants of pure *Zea canina* were also set near by. All three lots grew well, but Canina $\times$ Japanese was much the tallest and most vigorous. The one Canina $\times$ Marblehead plant grew scarcely more than four feet tall. Two suckers sprung from the base of the plant, but there were no branches higher up, and all the ears were small and single! The kernels, which had been pollinated from the tassels on the same plant, were indistinguishable from those of true Canina. The only effect of this hybridization with the sweet corn, therefore, was what might have been expected from so violent cross,—a general weakening of the characters of the plant.

The 14 Canina $\times$ Japanese grew with great vigor, reaching a height of eight and nine feet, and nearly all the stalks produced the branches of multiple ears. But the remarkable feature of these plants was the shortening up of these side branches from the length of two and three feet, attained in true Canina, as shown on page 332, to a cluster or brace of four to six ears, as shown on the next page. One plant which produced three stalks from the base, bore four sets on one stalk, five on another, and twenty-five on the main stalk, making a total of 34



Hybrid Corn.—Canina × Japanese.

ears from one seed! A portion of the main stalk of this plant is shown in the illustration. Some plants among these hybrids, however, produced single ears, but the greater number of them made from a dozen to twenty sets, and perhaps half the ears matured. The kernels in these remarkable hybrids are both yellow and white, although yellow is far the most prominent, and they are rounded like the Japanese, but bear a minute point or mucro in memory of their Canina parentage. The ears are twice larger than those of the Canina, from which they came. Two plants of the fourteen had distinctly striped foliage, like the Japanese corn.

The plants of true Canina which grew near by were less branched than the Canina × Japanese, and while most of the ears were multiple, some were single. This corn was also attacked by smut. The behavior of these plants indicate either that Canina is variable or that it tends to lose its characters under cultivation. I am inclined to adopt the latter explanation, especially as another lot of Canina grown in the field alongside a plan-

tation of sweet corn showed similar degeneration to single ears. This latter plantation stood besides the Cory sweet corn. Among this Canina only one plant matured, and that bore short ear-clusters, much like those shown on page 336, and the kernels were large and rounded, showing that it had been crossed with something the year before, probably an accidental mixture with Japanese, next which some of our Canina grew in 1891. The remaining Canina plants were still growing vigorously when frost came October 1, and some of them made the long arm-like branches, but several of them produced few and nearly simple ears. All these Canina plants were from seeds put into the ground June 15, for the purpose of testing their ability to ripen in one ordinary season. Now, the Cory corn alongside this Canina and which was grown from pure seed, seemed to show the effects of the Canina. There were many "rogue" kernels on the ears, being smooth and whitish and suggestive of Canina influence. It is known that maize often shows an immediate effect of pollen. No other corn grew within eighty rods of this plantation.

Our observations seem to show that *Zea canina* is losing some of its characteristic features under domestication, and that hybridization with the Japanese corn promises interesting and valuable results. Hybridization with sweet corn so far promises little in the origination of profitable varieties. It is by no means certain that we can preserve the wonderful prolificacy of the Canina $\times$ Japanese hybrid, but the experiments will be continued. In order to keep the stock straight until we determine if results of a somewhat permanent nature can be obtained, we propose to hold these corns entirely in our own hands for the present.

It may be worth while to enquire if this Canina corn still retains a specific identity, if it really is a distinct species from the common corn, *Zea Mays*. For myself, I am strongly of the opinion that it is not a distinct species. I am rather inclined to think, with the native Mexicans and Professor Dugès, that it is the original form of *Zea Mays*, or at least very near it. It explains many points in the evolution of Indian corn. Some varieties of sweet corn occasionally produce rudimentary multiple ears, and this Canina seems to tend to lose them under cultivation. The tendency of cultivation in all plants is to develop some fruits or

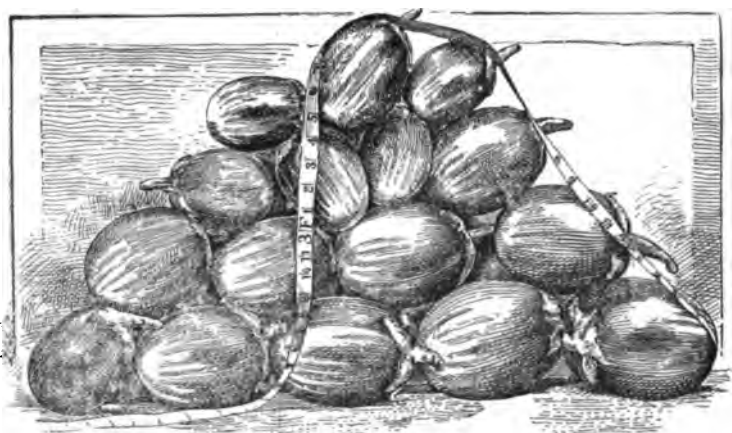
some organs, rather than all fruits or all organs. The suckering habit has been discouraged in the selection of corns. The tendency to sucker, the tendency to produce tassels on the ends of ears, the profuse drooping tassels of many little improved varieties, the predominance of flint corns northward and of dent or pointed corns southward, the occurrence of many curious and aboriginal corns in the Aztec region—all these become intelligible if *Zea canina* is the original of Indian corn.

THE BEHAVIOR OF SOME EGG-PLANT CROSSES.

In 1889, three crosses were made among egg-plants, one cross being between Round White and Black Pekin, one between Giant Round Purple and White Chinese, and the other between Long White and Black Pekin. In every case, the parents were very unlike, both in shape and color of fruit, and in color of plant. A number of plants were grown from these seeds in 1890, and the characters of the resulting offspring were fully explained and figured in Bulletin 26, March, 1891. The present report deals with the second generation, grown in 1891.

The cross which we called A was made between Round White and Black Pekin. The Round White is a small green plant which bears small, oblong, clear white, hard fruits. The Black Pekin is a large, dark purple plant which produces very large, nearly globular and very dark purple fruits. One fruit was obtained in 1889 as a result of crossing these two varieties. The seeds of this fruit gave in 1890 a series of plants which were almost exactly intermediate between the parents in size and other characters. The young shoots were much like the pistillate parent—Round White—but as they became older, the upper surface of the stems, the petioles and the veins of the leaves assumed the purple tinge of the male parent. In form and size, the larger part of the fruits seemed to vary in the direction of the pistillate parent, many of them being decidedly ovoid in form and very small. A few were larger, and had somewhat the form of the staminate parent. Frequently the same plant would produce mature fruits two inches and others five inches in diameter. In

color the fruits were purple while young,—first month or so,—usually dark purple with lighter apex. In some instances this color was retained till time of edible maturity; but as a rule, the dark purple changed to a dull greenish hue, and the light apex became metallic gray with a faint tinge of purple, and streaks of grayish-purple extended towards the base. The accompanying figure shows the extent of variation in 1890, or a fruit of every type obtained.



Extent of variation in the "A" crosses. (1890.)

From the first brood of this cross, 1890, eight fruits were selected or again crossed, as parents for succeeding crops. These fruits were essentially alike in color and shape, as shown in the above illustration. These eight fruits, which were the parents of the plants discussed below, were as follows:

- A1. Pollinated with another flower on the same plant.
- A2. Pollinated by Round White (original pistillate parent).
- A3. Pollinated by Black Pekin (original staminate parent).
- A4. Same as A3.
- A5. Pollinated with another flower on same plant, as in A1.
- A6. Same as A5.
- A7. Pollinated by Round White, as in A2.
- A8. Selection, not artificially pollinated.

From these eight fruits, 1405 plants were grown at Cornell in 1891.* The behavior of these plants is indicated by the table

*Duplicates of all these egg-plants have been grown in Maine by Professor W. M. Munson, who will soon report upon them.

which closes this article. It is interesting to note the influence of Black Pekin in A₃ and A₄, into which this variety has twice entered as a staminate parent. All the plants, 203 in number, were purple in foliage and like Black Pekin in habit; and most of the fruits were solid purple, although a few striped fruits still showed the influence of the Round White two generations back. The ones into which the Round White entered twice—A₂ and A₇—do not show so strongly the marks of the double infusion of blood. In A₂, there were a few more plants with green than with purple herbage and the green ones were more productive than the others; these are marks of the Round White, and it may



A Mongrel Egg-fruit. (1891.)

also be said that even the purple plants were of a light cast and that nearly all showed the influence of the dwarf habit of Round White. A₇, the other Round White cross, produced a lot of small plants, but they were unproductive, and much over half of them had purple herbage.

Three of these lots—A₁, A₅, A₆—were from fruits pollinated by a flower on the same plant. These, then, according to popular notions, should produce uniform plants; but with that sublime contrariness which is so characteristic of most of our results of crossing, these lots gave as variable progeny as those which had better right to such possessions. In fact, the lot A₁ was probably the most hopelessly mixed of any in the entire list. The

fruits ranged from pure white to green with white stripes, purple striped, light solid purple, and very dark purple; and the mature fruits varied from the size of an egg to that of Black Pekin. About equal numbers of the 175 plants were green and purple. A5 was nearly as badly mixed, and some plants appeared which had the peculiar spreading habit of Early Dwarf Purple, a variety which had never entered into any of the crosses. A6 showed wide variations also. A8, which was simply a selection and had not been artificially pollinated, was about as variable as the rest.

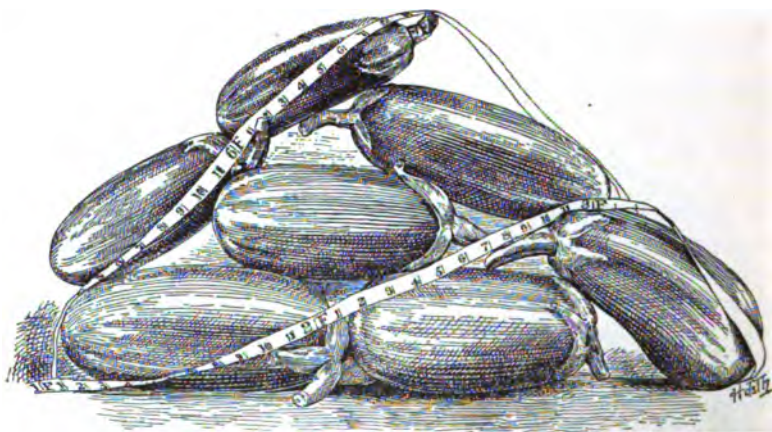
Some of the fruits of these crosses were exceedingly handsome, especially one which appeared in A1 and another in A2. The engraving on last page shows one of them, but no black and white print can do justice to it. White and purple bands were laid on the fruit in alternate waves which seemed to run off the fleshy calyx lobes and to flow down the fruit. Efforts have been made to perpetuate these remarkable types, but they are now lost. Every new attempt at crossing reminds me that the chief value of the operation is the infusing of new vigor into offspring rather than the origination of new types.

As a whole, 543 of the 1405 plants produced perfectly green foliage, showing the effect of the Round White. Most of the fruits produced by these eight samples were of an indifferent and ill-defined color, and were utterly worthless for market. In productiveness, the purple-herbage plants were ahead of the green ones, although the green parent—Round White—is more productive than the Black Pekin. Of the 729 plants which gave sizable fruits before frost, 454 were purple and 275 green. In habit, the A crosses were also very various. The Round White seemed to exert a great influence upon the stature of the plants, but the purple color of Black Pekin appeared to be more potent than the green of the other.

Series B came from a cross of Giant Round Purple and White Chinese. The former has purple herbage and a very large purple fruit, while the latter has green herbage and a long club-shaped white fruit. So far as beauty of form and color is concerned, this series was by far the most promising of the three crosses. The plants in this series, as in the former, were as a rule intermediate between the parents. Much of the vigor of the pistillate

parent was transmitted to the offspring, but the leaves were smaller and less distinctly lobed.

In form the fruits, as a rule, resembled the staminate parent—White Chinese, but they were of greater diameter. The color at edible maturity was rich dark purple, with lighter apex. When fully mature—that is when left for the seed to ripen—the light purple apex became gray, then yellowish like the staminate parent, while the dark purple body of the fruit became dull green.



Extent of variation in "B" crosses. (1890.)

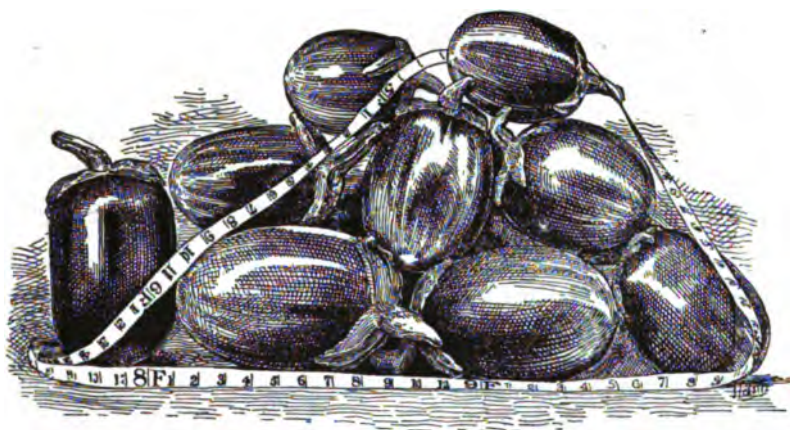
The full extent of variation in this series is shown in the illustration. Eight of these fruits grown in 1890 were selected or again crossed for planting in 1891. These B lots originated as follows :

- B1. Pollinated by Giant Purple (original pistillate parent).
- B2. Pollinated with another flower on the same plant.
- B3. Pollinated by Giant Purple, as in B1.
- B4. Pollinated with another flower on same plant, as B2.
- B5. Pollinated by Giant Purple, as in B1 and B3.

B6. } Selections, not artificially pollinated. These were attractive fruits
 B7. } of a purple color and lighter apex, tending to be striped.
 B8. }

The offspring of these fruits—479 plants—showed a wide variation in color of herbage, many of them being green, although the greater part of them were purple. As a whole, however, these plants were comparative uniform in size and habit, and could be distinguished from the A and C series at a considerable distance.

The plants were low and bushy, but erect, mostly with a grayish-purple tinge when seen in mass. B₂, which was pollinated from another flower on the same plant, gave as various fruits as the others. Of eighteen large fruits of it, one was very black-purple, six were light purple, and one was purple-striped, nine were green-and-white striped, one was pure white. It is strange, too, that one of the plants of this lot had the peculiar habit of Early Dwarf Purple, a variation also found in one of the A series (A₅) which had been similarly pollinated. The lots into which the original pistillate parent, Giant Purple, was again impressed — B₁, B₃, B₅ — showed very variable offspring, although there were large numbers of purple and purple-striped fruits in the progeny. B₃ and B₅ were very much alike in habit, color and fruit. There was comparatively little variation in any of the B lots.



Extent of variation in "C" crosses. (1890.)

Series C originated from a cross of Long White by Black Pekin. This series, then, is much like A in parentage, except that the pistillate parent has longer fruit. The effect of the staminate parent in giving color to the foliage was more marked than in series A. In no case was there an absence of the purplish tinge of Black Pekin, and frequently the color was nearly as deep as in the parent. The fruit was of intermediate color, but with the purple predominating. In form, a few of the fruits resembled the

staminate parent; and many resembled the pistillate parent, while others were wholly distinct.

Four fruits were again crossed or selected in 1890 from this series:

- C1. Pollinated by another flower from same plant.
- C3. Pollinated by Black Pekin (original staminate parent).
- C4. Selection, not artificially pollinated. Seen at the extreme left in the illustration. It was very angular at the ends, purple with a metallic-gray apex.

In these lots, the fruit pollinated from the same plant, C1, gave a variable and very unproductive offspring. C3, into which Black Pekin has gone twice, gave only purple fruits. C4 was the one which we particularly desired to fix, for the original fruit had strong points of merit. This fruit gave us 169 plants, none of which, however, were like the parent, and none seemed to possess superior merits. Only 31 of the plants from it produced fruits before the frost, and of these 5 had green herbage and 26 purple herbage. All the C plants were very tall in 1891, mostly dark in foliage, and late.

The result of all this experiment with secondary crosses and the second generation of primary crosses, numbering 2126 plants, shows that they were exceedingly variable, that pollination from the same plant did not fix the types, that very few novel and promising types appeared, that the white and purple colors tend to unite to produce striped fruits, and that the greater part of the crop was unsalable because of the nondescript colors of the fruits. And all this only emphasizes the fact which we have learned with many other plants, that crossing for the purpose of producing marked novelties for propagation by seed is at least unsatisfactory.

The following table showing the numerical measures of this variation may interest those who are curious concerning plant variability:

VARIATION IN EGG-PLANT CROSSES.

Samples.	Whole number of plants.	No. with green herbage.	No. with purple herbage.	Whole No. of fruitful plants.	Number fruit-ful plants with green herbage.	Number fruit-ful plants with purple herbage.	No. frts. dark as Black Pekin.	No. frts. light purple.	No. frts. purple striped.	No. frts. green with white stripes.	No. frts. white.	REMARKS.
A1	175	83	92	92	43	49	8	20	20	28	26	Mostly a good lot but very variable. { Shows a tendency to revert to Round White; none of the purple plants so dark as in A1. { Much like Black Pekin. although there are { some green-striped fruits
A2	102	82	21	78	65	13						
A3	86	0	86	68	0	68						
A4	117	0	117	97	0	97						
A5	291	119	172	136	55	81						{ Some plants are low and diffuse like Early Dwarf Purple, but its fruits are different. Plants very various. Plants small and unproductive.
A6	216	89	127	121	54	67						
A7	244	101	143	76	32	44						
A8	174	69	105	61	26	35						
B1	49	—	—	22	2	20	4	4	15	2	0	Fruits long, like Long Purple. Mostly tall, but one plant with habit of Early Dwarf Purple. { Plants remarkably uniform in size and ap- pearance. Grayish in color, with light { purple tinge.
B2	30	—	—	12	8	4	1	6	1	9	1	
B3	96	—	—	36	0	36	0	0	36	0	0	
B4	2	—	—	1	—	—	0	1	0	0	0	
B5	79	—	—	34	0	34	15	15	6	0	0	Like B3. Like B3, but plants somewhat smaller. Plants like B6. Like B6 in aspect.
B6	42	—	—	4	2	3	0	0	2	1	0	
B7	73	—	—	6	2	4	0	6	0	2	0	
B8	108	—	—	17	9	8	0	4	5	4	0	
C1	39	—	—	3	1	2	3	0	0	0	0	Mostly tall, but occasionally a low plant. Occasionally a low plant.
C3	34	—	—	15	0	15						
C4	169	—	—	31	5	26						

FERTILIZERS FOR GRAPE CUTTINGS.

It is often a very serious question with nurserymen what fertilizers they shall use to produce the largest and best grape-vines, especially in the dryer seasons when growth is small. Two years ago we undertook an experiment in this direction, and T. S. Hubbard of Fredonia, N. Y., a well-known nurseryman, gave us 10,000 cuttings of Concord with which to make the test. These cuttings were divided into ten equal lots and each lot was set in the spring of 1891 upon a plot 10x25 ft. The cuttings stood 3x12 inches apart. The plots were arranged in two rows, and they received treatment as follows in 1891 and 1892:

- | | |
|---|---|
| 1. Check
(no fertilizer). | 6. Cotton-seed meal
(4 lbs. a year). |
| 2. Cotton-seed hull
ashes (4 lbs. a year). | 7. Bone flour
(4 lbs. a year). |
| 3. Muriate of
potash (2 lbs. a year). | 8. Stable manure
(40 lbs. a year). |
| 4. Nitrate of soda
(2 lbs. a year). | 9. Bradley's super-
phosphate (4 lbs. a year). |
| 5. Sulphate of ammonia
(2 lbs. a year). | 10. Check
(no fertilizer). |

These fertilizers were applied May 14, 1891, and June 23, 1892. They were sown upon the ground and found their way under the surface at the regular hoeings. The soil upon which these cuttings were grown was a poor and very hard gravel. This soil was selected because it had received no fertilizers in recent years and because the results of the different materials would be undisguised by the heavy growth which would be given by a good soil. The early season of 1891 was very dry and many of the cuttings did not start. Later in the season, the remaining plants made a fair growth but no difference could be seen in the plots. It was evident that the fertilizers had not yet reached the roots of the plants. But in 1892 the effect began to be marked early in summer, and it was evident that plot No. 4—nitrate of soda—would distance all the rest. Final observations were made October 19, when it was found that plot No. 4 was best and No. 5 second. These plots gave easily fifty per cent. more growth than any of the remaining eight. No. 2—cotton-seed hull ashes—was the best of

the remaining plots, although its advantage was slight. Between the other seven there were no obvious differences.

Plot 4—nitrate of soda—was conspicuously darker in foliage than any other throughout the season. The vines matured well, although the yellow leaves still hung to the plants in the middle of October. Plot No. 5—sulphate of ammonia—was perhaps ten per cent. below No. 4 in amount of growth, and the wood was not so well ripened as in the other.

THE BLACK-KNOT OF THE PLUM AND CHERRY.

THE NEW YORK LAW.



Black-knot.

The black-knot is a serious disease, attacking the branches and twigs of the plum, sour cherries, and sometimes sweet cherries. It is also common upon wild choke-cherries, from whence it spreads to the orchards. The most prolific source of the disease, however, are the neglected hedge-rows of plums and Morello cherries along road-sides and about old buildings. Sometimes black-knot will be noticed sparingly in a community for several years before it seriously attacks cultivated trees, and this fact has caused people to become indifferent to it; but sooner or later it will spread and become a most pernicious evil. Plum growing is abandoned in some parts of the Hudson river valley because of the incursions of black-knot, and a similar fate is likely to overtake any community which neglects it. It is the duty of every citizen to exert himself towards the extirpation of this pest, and New York and Michigan now have laws to compel its removal.

Black-knot is a fungous disease, and the only reliable treatment yet known is to cut off the knots and burn them. This opera-

tion should be done just as soon as the leaves fall, at the latest. Good plum growers inspect the trees once or twice during the summer if black-knot is feared. Always burn the knots ; if they are not destroyed the spores of the fungus will still develop, even after the knot is cut from the tree. The old knots often contain worms, but these only burrow in the spongy tissues ; they do not cause the disease.

The following is the New York law. Every citizen should support it :

SECTION 1. It shall be unlawful for any person knowingly or willfully to keep any plum, cherry or other trees infected with the contagious disease or fungus known as the black-knot ; that every tree so infected is hereby declared to be a public nuisance, and no damages shall be awarded in any court in this state for entering upon premises and cutting away or severing the diseased part or parts of any tree so infected and destroying the same, or cutting down or removing such infected tree altogether and destroying the same, if done in accordance with the provisions of this act.

§ 2. In any town or city in this state in which such contagious disease exists, or where there is good reason to believe it exists or danger may be justly apprehended of its introduction, it shall be the duty of the supervisor or mayor of any town or city upon the application made in writing and signed by at least three freeholders, who are residents of said town or city to appoint forthwith three competent freeholders, who shall be fruit-growers, of said town or city as commissioners, who shall hold office during the pleasure of said supervisor or mayor, and such order of appointment and of revocation shall be entered at large on the town or city records.

§ 3. It shall be the duty of said commissioners, within ten days after appointment as aforesaid, to file their acceptances of the same with the clerk of said town or city, and said clerk shall be ex-officio clerk of said board of commissioners, and he shall keep a correct record of the proceedings of said board in a book to be provided for the purpose, and shall file and preserve all papers pertaining to the duties and actions of said commissioners, or either of them, which shall be a part of the records of said town or city.

§ 4. It shall be the duty of the commissioners, or any one of them, upon or without complaint, whenever it comes to their notice that the disease known as the black knot exists, or is supposed to exist, within the limits of their town or city, to proceed without delay to examine the trees supposed to be infected, and if the disease is found to exist a distinguishing mark or marks shall be placed upon that part or those parts of every tree so infected, which in the judgment of the commissioner or commissioners should be removed and destroyed, or if in the judgment of such commissioner, or commissioners any tree so infected should be entirely removed and destroyed, then the trunk of such trees shall be thoroughly girdled, and a written notice given to the owner personally, or by leaving the same at his usual place of residence, or if the owner be a non-resident by leaving such notice with the person in charge of such trees. The notice shall contain a simple statement of the facts as found to exist, with an order to effectually remove and destroy by fire the part or parts of every tree so marked and designated, or every such tree entire which shall be so girdled, as the case may be, within ten days from the date of the notice above required. Such notice and order to be signed by the three commissioners, or any two of them.

§ 5. Whenever any person shall refuse or neglect to comply with the order mentioned in the last section, it shall become the duty of the commissioners to carry out the directions of said order, and forthwith to remove and destroy by fire every tree, or part of a tree, so girdled, or marked, as aforesaid, employing all necessary aid for that purpose; the expenses for such removal and destruction to be a charge against the town or city; and for the purpose of such removal and destruction, the said commissioners, their agents and employes, shall have the right and authority to enter upon any and all premises within their town or city.

§ 6. If any owner, or if such owner be a non-resident, then if any person in charge of such trees, neglects to remove and destroy by fire every tree, or part of a tree, so found to be infected, and marked, or girdled, as aforesaid, after notification, and within the time hereinbefore prescribed, such person shall be guilty of a misdemeanor and punished by a fine not exceeding twenty-five dollars or by imprisonment in the county jail not exceeding ten

days, or both, in the discretion of the court; and any justice of the peace of any town or city, in which said offense shall be committed, shall have jurisdiction thereof; and all such fines so collected shall be turned over to the supervisor of said town, or other proper officer, to be placed by him in the contingent fund of said town or city.

§ 7. The commissioners shall be allowed for service under this act two dollars each for each full day and one dollar each for each half day, and their other reasonable charges and disbursements hereunder to be audited, as well as any other charges and disbursements under this act, by the board of town auditors or proper city officers, to be paid to such commissioners as other town or city accounts are paid. Such fees and all reasonable charges and disbursements of said commissioners, in each case may be recovered by the town in the name of the supervisor, and in cities in the name of the city, from the owner of the diseased trees, on account of which such fees, charges and disbursements become payable or were incurred.

§ 8. This act shall take effect immediately.

Approved by the Governor, May 12, 1892.

THE WILD POTATO OF THE MEXICAN REGION.

About 1878 Dr. W. J. Beal of the Michigan Agricultural College received from the Harvard Botanic Gardens a few tubers,—the largest about an inch in diameter—of a wild potato from Mexico. This potato has been grown since that time at the Michigan College, and we have grown it here two or three years, from the Michigan seed. The tubers are gradually improving, and in 1887, when I made a report upon this potato,* the best tubers measured three inches in length. The largest tubers now reach over four inches in length, and the number of small potatoes in the hills seems to be lessening. The illustration shows an average sample of this potato as dug in our gardens this year. The tubers are brown, with deep eyes, and tend to be flattened.

*Bull. 31, Mich. Expt. Sta. 87.

They keep well. The flesh is very yellow. When cooked, the flavor is rich and possesses a slight aroma which is not present in the common potatoes. The plants usually produce balls freely



Mexican Wild Potato.

This potato is, probably, the *Solanum tuberosum* var. *boreale* of Gray, although it has the interposed small leaflets which that plant is supposed to lack. It occurs in a wild state from the Montezuma valley, Colorado, to New Mexico southwards in the mountains in Mexico. This wild potato of the north appears to have been first brought to notice in 1856 by Dr. A. J. Myers, of the United States Army, who found it in Western Texas. He sent specimens to Asa Gray, who named it *Solanum Fendleri*, in honor of Augustus Fendler, an early botanical explorer of the Southwest. Dr. Gray afterwards considered it to be only a geographical variety of the potato and renamed it *Solanum tuberosum* var. *boreale*. The account of the plant as seen by Dr. Myers, contains the following reference to the tubers: "The tubers, though small, being rarely as large as a hickory-nut, have been gathered, cooked and eaten by officers and soldiers, and they proved both palatable and innocent." This plant was grown in 1888 by the Colorado Experiment Station from wild Colorado tubers. The tubers under cultivation were "quite large

relatively to the other forms [samples of *Solanum Jamesii*], oblong in shape, and of a dark brown color." * Several crosses were made in Colorado upon this wild potato from pollen of common potatoes, but I am not aware that any subsequent report has been made upon them. The Wild Mexican potato has been grown by several experimenters for a number of years. Their reports would be interesting.

DO FERTILIZERS AFFECT THE QUALITY OF TOMATOES?

There is much discussion concerning the supposed effects of different fertilizers upon the quality—solids, sugar, acids—of tomatoes. Samples of tomato fruits were taken September 6 from various fertilizer plots for chemical examination.† In the following table each entry or sample means a single fruit. The fruits selected were well colored and of medium size and ripe enough for dessert use. All the samples are Ignotum.

The fertilizer plots from which these fruits were taken are of two series. The samples 1 to 8 are from a general test to determine the values of nitrogen, potash and phosphorus, alone and in combination. Six plants constituted a plot, and the fertilizers were sown on the surface June 20. The yields of these plots are shown in Table IV, page 195, of our last tomato bulletin (No. 45).

Samples 9 to 11 are from a series of plots designed to determine the relative merits of single and intermittent applications of nitrate of soda (Tables I, II, III, Bulletin 45). These plots contained 15 plants each. Samples 9 to 9c are from a plot which received a single application of nitrate of soda of 3 lbs. June 20; No. 11 received the same total amount in four applications.

Samples 12 and 12a are from a plot to which a liberal dressing of good, fine stable manure was applied.

The soil in all these plots is a fairly good, dry and high gravelly loam.

*Bull. 4, Colo. Expt. Sta., 14.

†The method of chemical analysis is discussed upon page 301 of this bulletin.

DO FERTILIZERS MODIFY QUALITY OF TOMATOES?

Samples.	Field Treatment.	Selection of samples.	Solids.	Sugar.	Acid.
1	Nitrate of soda, 1 lb.....	3 fruits from 3 plants....	5.57%	1.41%	.44%
1a	" ".....	" ".....	6.07	—	.47
1b	" ".....	" ".....	5.72	.94	.57
3	Muriate of potash, 1 lb.....	2 frts. from same cluster.	5.88	—	.38
3a	" ".....	" ".....	5.42	—	.37
4	Nitrate soda, 1 lb., Bone black, 2 lbs.....	2 frts. from 2 plants.....	5.26	1.15	.34
4a	" ".....	" ".....	6.17	1.47	.59
5	Nitrate soda, 1 lb., Muriate potash, 2 lbs.....	5 and 5a from one plant; 4.97	4.90	.69	—
5a	" ".....	5b from another plant.	5.54	.92	.75
5b	" ".....	" ".....	—	1.22	—
6	Bone black, 2 lbs., Muriate potash, 1 lb.....	2 fruits from 2 plants.....	5.76	—	.44
6a	" ".....	" ".....	5.90	1.01	.36
7	Nitrate and Muriate, 1 lb each.....	2 fruits from one plant....	6.49	—	.35
7a	Bone black, 2 lbs.....	" ".....	6.10	.89	.45
8	Check (no fertilizer).....	2 fruits from one plant....	5.52	1.07	.54
8a	" ".....	" ".....	5.40	—	.38
9	Nitrate soda.....	9 and 9a from one plant; 5.71	3.89	—	.44
9a	" ".....	9b and 9c from another plant.....	5.77	.97	.58
9b	" ".....	" ".....	5.58	—	.39
9c	" ".....	" ".....	—	—	.33
10	Check (no fertilizer).....	" ".....	6.56	.58	.44
11	Nitrate soda, applied June 20, July 21, Aug. 8, Aug. 26.....	" ".....	6.04	—	.72
12	Stable manure.....	2 fruits from 2 plants.....	5.91	—	.51
12a	" ".....	" ".....	5.97	.90	.37

It is plain from these figures that there was no uniform variation in the quality of the tomatoes. The differences are as wide between different fruits of the same plot as between the different plots. The variations in sugar in the samples from the same plot are well shown in 5, 5*a* and 5*b*, in which the readings run from .69 to 1.22. We hope to repeat the experiment the coming season.

THE VETCH OR TARE AS AN ORCHARD PLANT.

Orchard lands are nearly always benefited by some cover or mulch during a part of the year, especially during fall and winter. One of the values of sod lies in the protection to the soil, but a sod cannot be obtained in a single season. If orchards can be cultivated in spring and early summer and then protected with some growth which will shade the soil and keep it moist during the remainder of the warm weather and afford some protection from frost during winter, the best results will undoubtedly be obtained, as a rule. This cover crop should also afford fertilizing materials to the soil when turned under, and greatly improve the mechanical character of the soil, as well.

The leguminous plants—those belonging to the clover family—at once suggest themselves because they are rich in nitrogen, and may therefore serve both as cover and fertilizer. We have tried mixed beans and field peas, but there are objections to both, although either one is probably better than weeds or bare ground. This year we have tried the European vetch or tare (*Vicia sativa*), seed of which we obtained of J. M. Thorburn & Co., New York. This plant is grown for forage in England. A half bushel of seed was sown June 16 upon five-eighths of an acre of heavy clay loam. It was sown broadcast upon a freshly prepared surface, and well dragged in. The seed could have been sown later with equally as good effect, no doubt, and the cultivation of the orchard could have been continued for ten days or two weeks longer. The young trees of pear, plum and apricot have made an excellent growth this year among the vetch. The vetch started

somewhat slowly and the seeding seemed to have been too thin ; but by the middle of September the ground was covered thickly. Frost came October 1, but the vetch was not injured and it continued to grow until the middle of the month, and remained green still longer. It made a remarkable cover, growing knee-high in a dense mat and everywhere completely covering the ground. It began to flower in September, but no seeds ripened except upon a few poor spots. Upon light soils, seeds would probably form freely, but the plant is an annual and is not likely to become a weed. The roots do not extend deep. With the approach of hard freezing weather, the stalks fell upon the ground, where they now lie like a thin even covering of old hay. The stems are soft and can be easily plowed under in spring and will soon decompose ; and they will not keep the soil wet too late in spring, which is an important point upon clay soils. On the whole, we are much pleased with the vetch as an orchard plant, and shall use it again.

Samples of this vetch, including four to six inches of the roots, gave the following fertilizer analysis :

	Original substance.	Dry substance.
Nitrogen.....	.65 per cent.	3.10 per cent.
Phosphoric acid (P_2O_5)....	.146 "	.70 "
Potash (K_2O).....	.475 "	2.28 "
Water.....	79.15 "	

Compared with clover, the fertilizer value is high. The following are summaries of several analyses of red clover :

	Dry substance.
Nitrogen.....	2.05 per cent.
Phosphoric acid.....	.66 "
Potash.....	2.24 "

SUBSTITUTES FOR GLASS IN GREENHOUSE ROOFS.

There is much inquiry for some cheap substitute for glass for greenhouses, and various preservative preparations are recommended for the treatment of cloth and paper to be used in roofing. We have tried paper one season and cloth two seasons, and find both to be entirely unsatisfactory for a winter roof in this climate. They are cold, dark, and not durable. For summer or late spring use, oiled muslin is fairly satisfactory. Plants which require a

heavy shade in summer can be grown to advantage under such a roof. In the summer of 1891 we found a cloth-roofed house to be an excellent place for flowering the tuberous begonias. Cloth roofs, with ordinary oil treatment, last less than a year, and paper is so easily torn and punctured by drifting twigs that we consider it nearly useless for roofs. It will also tear after a short time by a heavy wind from the inside if a door or ventilator chances to be open. The cost of a few annual roofs of this character will pay for a glass roof. Even if the cloth were to last for two or three years, it would soon become very dark from a collection of dirt and the growth of mildew.

Our first experience with these covers was the use of paper in the fall of 1890. The paper used was a thin white, stiff, architect's drafting paper known in the trade as "Economy." This was laid over the sash-bars and was held down by the caps used for holding butted glass. It was then thoroughly saturated with raw linseed oil. It had been in place but a short time when an ambitious cat attempted to walk over it, and made a hole at about every other step. After a few weeks of vexation, the paper was removed, and a medium quality of unbleached muslin cloth was substituted, being laid on in the same way. This muslin was oiled twice with raw linseed oil. This was in December. The cloth lasted until late spring, but became very black and dirty towards the last. In the fall of 1891, another covering of the same muslin was laid, and this received three coats of raw oil. This lasted until the next summer.

This roof is now covered with glass.

L. H. BAILEY.

Bulletin 50.

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Cornell University Agricultural Experiment Station.

ENTOMOLOGICAL DIVISION.

THE BUD MOTH.



By MARK VERNON SLINGERLAND.

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Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1893.

50. The Bud Moth.

THE BUD MOTH.

Tmetocera ocellana.

Order LEPIDOPTERA ; family GRAPHOLITHIDÆ.

Nearly every year some injurious insect makes its appearance in sufficient numbers to alarm the fruit growers of this State. In 1891, not only did the pear growers suffer severely from the Pear Psylla,* but the apple growers also had much of their fruit destroyed while yet in the bud by an insect known as the Bud Moth.

During May and June, 1891, this Department of the Station received a large number of inquiries regarding the pest which was then at work in many counties of the State. The letters indicated that the pest was the most prominent apple pest of the season.

As the insect attacks the opening leaf and flower buds, the destruction wrought is often very great. The reports from some localities in the great fruit growing districts in the western portion of the State showed that nearly the whole crop on many trees was destroyed while yet in the bud. The pest was also especially destructive when it attacked recently budded or grafted trees and young nursery stock. The attack was not confined to the apple alone, but pear, plum, cherry, quince, and peach trees also suffered.

Thus the fruit growers have to fear, in the Bud Moth, a pest which is capable of literally "nipping in the bud" a prospective crop of fruit, a graft, or a budded stock.

*This pest was discussed in Bulletin 44, Cornell University Agricultural Experiment Station.

THE PAST HISTORY OF THIS PEST.

This insect had been known for more than half a century in Europe before it was recorded in this country. The Bud Moth, therefore, like many of our worst insect pests, was no doubt an importation from Europe. The insect is common in nearly all parts of Europe and there became of economic importance about 1840, or about the same time it was recorded here as injurious by Dr. Harris.

Dr. Harris' account (1841) seems to be the first notice we have of the appearance of the pest in this country. It had probably been imported, while in hibernation, from Europe upon nursery stock some years before. After 1841, we have no record of the insect having been injurious until 1869. Then Dr. Packard (Rept. Mass. Bd. Agr. for 1869) found it to be "the most injurious enemy of the apple-tree, next to the Canker worm, that we have in this (Mass.) State." In the same year the pest did some damage in Pennsylvania (Am. Ent., I, 251). In 1870, the insect damaged plums in Ontario, Canada.

Although Dr. Fitch mentions the insect as an apple-tree pest in his Third Report (1856), he does not record it as found in our State. And it is not until 1880 that we find any record of the occurrence of the pest in New York State. Then Prof. Comstock while U. S. Entomologist received the insect from nurserymen at Union Springs, N. Y. In the previous year, as the notes of the Department at Washington show, Prof. Comstock had found the pest at work on the Department grounds at Washington. By 1885, the pest had reached Nova Scotia where Mr. Fletcher found it hibernating on the twigs (Rept. Dept. Agr. of Canada for 1885).

Dr. Lintner records the pest as quite injurious near Rochester, N. Y., in 1887. In 1888, Prof. Harvey (An. Rept. Maine Expt. Sta. for 1888, p. 169) found the pest doing considerable damage to apple buds in Maine; and in his Report for 1890, he records a very serious attack of the insect upon blackberry buds at Rockland, Me. Throughout Massachusetts, New York, and Canada, the pest appeared in increased numbers and was very destructive in 1891. Prof. Cook also records it as doing unusual harm in Michigan during 1892. (Fourth An. Rept. Mich. Agr. Expt.

Station, 1891). December 17, 1892, Dr. Riley wrote us regarding the distribution of the pest as follows: "In the last two or three years I have received it from several localities in New England and the Middle States, and the labels upon the specimens in the National Museum show that it has also been received from Missouri."

It is thus seen that this pest which seems to have first appeared in this country in Massachusetts about 1841, has now become widely distributed over the New England, Middle States and Canada; and it has spread southward to Washington, D. C., and westward into Missouri.

ITS CLASSIFICATION.

This pest is one of the Micro-Lepidoptera and belongs to the group of moths known as the *Tortricina*. According to the latest systematic arrangement of the Lepidoptera, the insect is closely allied to the well known Codlin Moth, *Carpocapsa pomonella*; and the adult insect does resemble the Codlin Moth in size and form, but it differs from it in structure, in coloring, and in its habits and life history.

Its generic name *Tmetocera* (meaning cut-horned in the original Greek) was established in 1859 for the reception of this insect which still remains the only representative of the genus thus far known; the notched appearance of the base of the antenna* of the male moth (Fig. 3 c) suggested the name, and seems to be the principal generic character. The specific name *ocellana* (from the Latin for eye-like) was given to the insect in Austria in 1776, more than a century ago; a spot somewhat eye-like in appearance, on each front wing of the moth, suggested the name. The Eye-Spotted Bud Moth is a common name given to the pest by some entomologists. The moth has been described under five different names, and the species has been placed in six different genera. All of these names are now brought into the synonymy of *Tmetocera ocellana*.

*The joints are not notched, but a notched appearance is caused by the scanty clothing of the fifth joint, the peculiar arrangement of the scales on the third and fourth, and the spurs on the sixth and seventh joints.

INDICATIONS OF ITS PRESENCE.

The pest makes its presence known early in the spring as soon as the buds begin to open, usually about May 1 on early varieties and a week or ten days later on late varieties. Our correspondents reported that in 1891, Greenings, Baldwins, and Kings suffered the most. The caterpillars work in opening fruit and leaf buds, often eating into the buds, especially the terminal ones, so that all new growth is stopped. Such work in but a few buds on a nursery tree especially, soon checks and disfigures its symmetry of growth and often spoils the tree for marketing. This fact makes this insect one of the worst pests to be dreaded by nurserymen. On larger trees, unless the pest is very numerous, this disfigurement of the natural growth is not so noticeable.

More often the pest does not begin its work until the buds are nearly half opened. In this case the caterpillars feed upon the central portions of the buds, if a fruit bud upon the unopened flowers. The central leaves and flowers are tied together with silken threads, and when the pest needs more food it draws in and fastens an outer leaf or flower. In a short time some of the partly eaten leaves in this nest turn brown and become detached from the branch, thus rendering the work of the pest quite conspicuous. So many of the leaf and flower clusters were thus webbed together and so many of the leaves had turned brown in one instance, that a correspondent wrote May 25, 1891, that some of his trees looked as though a fire had been through them. This tying together of the leaves and flowers and the brown appearance of many of the leaves are the most characteristic indications of the presence of the pest on large trees.

In some cases, especially on the tender shoots of young trees, the caterpillar after destroying the bud, burrows down the center of the shoot, thus causing it to die back for several inches.

Later in the season, in July, the work of the recently hatched caterpillars may be seen on the under side of the leaves (Fig. 7). They feed upon the lower side of the leaf near the mid-rib, leav-

ing the veins and upper epidermis of the leaf. As the area over which the caterpillar has fed soon turns brown, its work is quite easily seen. The number of leaves found thus affected in July and August will indicate whether the pest will be numerous the coming spring or not. The reason for this will appear when we treat of the life history of the pest.

There is nothing about the appearance of the tree itself in winter that would indicate whether the pest was present or not. As the caterpillars hibernate and are so securely hidden, it would be very difficult for an ordinary observer to find them and thus to determine whether the pest is present in alarming numbers.

THE APPEARANCE OF THE PEST.

The larva or caterpillar.—This is the stage of the insect which is the most familiar to fruit growers. When first hatched, the larvæ are only about .04 of an inch (1 mm.) in length, slightly hairy, and of a light green color with a dark brown shield on the first thoracic segment; the head is nearly twice as wide as the body and of a shining dark brown color. In a few hours the larva changes to a light seal brown color and the head and thoracic shield become nearly black. The larvæ go into hibernation when about half grown, and appear upon the opening buds in the spring as little light brown caterpillars, about .16 of an inch (4 mm.) long, with a black head and thoracic shield; the anal shield on the dorsum of the last segment is scarcely darker in color than the body.



FIG. 1.—*The larva, about three times natural size.*

In June when the larvæ are full grown (Fig. 1) they measure about one half an inch (13 mm) in length and are of a cinnamon brown color, with the head and thoracic shield shining black and the anal shield sometimes considerably darker than the body. Light colored hairs arising from minute dark spots on slight elevations sparsely clothe the body. The three pairs of true legs borne by the thoracic segments are black; the five pairs of pro-legs are of a fleshy nature and borne by the fourth, fifth, sixth, seventh, and last abdominal segments.

The pupa.—This is the quiescent stage through which the insect passes in changing from the larva to the adult. If the nests

made by the larvæ be examined in the latter part of June the pupæ may be found in a tube of dead leaves. Fig. 2, *a* and *b* represent in outline the ventral and dorsal aspects of the pupa. It is about .27 of an inch (7 mm.) in length and of a light brown color. Each segment of the abdomen is provided on the dorsum with two rows of small tooth-like processes pointing caudad, and there are several hook-like bristles projecting from the caudal segment.

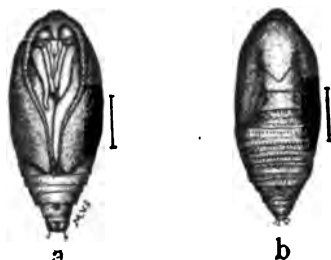


FIG. 2.—The pupa; *a*, ventral view; *b*, dorsal view.

The moth or adult insect.—Dr. Fernald describes the moth

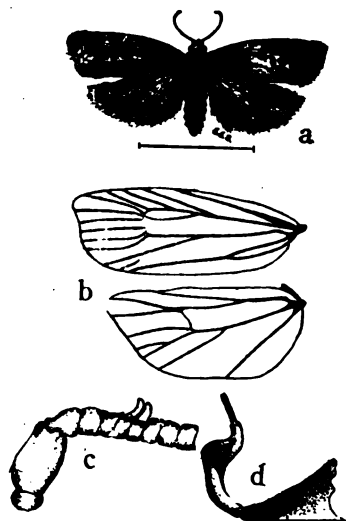


FIG. 3.—The adult, *a*, twice natural size; *b*, venation of the wings; *c*, basal joints of antenna of male, much enlarged; *d*, genitalia, one harpe much enlarged.

(Fig. 3, *a*) thus: "The fore wings expand about three-fifths of an inch. The head, thorax, and basal third of the fore wings, and also the outer edge and fringe are dark ashen gray, the middle of the fore wings is cream white, marked more or less with costal streaks of gray, and in some specimens this part is ashy gray, but little lighter than the base. Just before the anal angle are two short horizontal black dashes followed by a vertical streak of lead blue, and there are three or four similar black dashes before the apex, also followed by a streak of lead blue.

The hind wings above and below and the abdomen are ashy gray. The under side of the fore wings is darker, and has a series of light costal streaks on the outer part." At *b*, figure 3 is shown the venation of the wings; *c*, represents the peculiar structure of the basal joints of the antennae of the male moth; *d*, represents one side of the genitalia of the adult male.

THE LIFE HISTORY OF THE INSECT.

The more one can learn about the habits and life history of an insect pest, the easier it will be to intelligently combat that insect. The minutest details of the where, how, and when the insect works are always of interest and oftentimes reveal the weak and vulnerable point in their defensive armor. In order to study with accuracy the habits of an insect it is necessary to place the insect under conditions, in the field if possible, and if not then in the laboratory, where it can be watched almost constantly and yet have the conditions as nearly natural as possible. The same insect may differ in its life history in different localities under the different climatic conditions. For instance, the Elm-Leaf Beetle (*Galeruca xanthomelæna*) develops two broods in the vicinity of Washington, D. C., while in its spread northward it has become single brooded in Northern New Jersey. Again, the Squash-Vine Borer (*Melittia ceto*) according to the observations of Prof. J. B. Smith is single brooded in New Jersey, but Prof. D. S. Kellicut finds it to be double brooded in central Ohio. These instances show the need of supplementing the observations of others by a study of the insect in one's own locality. In fact, were it not for just such complete studies of the habits and life histories of our worst insect pests, it would not be possible for farmers and fruit growers to be so successfully fighting these minute foes.

Our study of the life history of this Bud Moth has afforded a striking example of the importance of the above facts. It has been found necessary to watch the insect in its various stages almost constantly to learn its habits; and this detailed study has revealed what appears to be the only weak point in its armor. And again our observations show that the pest has quite different habits in this State from what it has in Massachusetts, if the recorded observations of one of our leading entomologists are correct; this difference will be seen to be of vital importance when we come to discuss the preventive measures to be used against the pest.

Although the larva and pupa of the Bud Moth were known more than eighty years ago, but little was recorded of its life history until 1840. Then Schmidberger recorded that in Austria the moth laid her eggs in June on the fruit and leaf buds where they remained unhatched all winter, the larvæ emerging as soon

as the bud began to swell in the spring. Although considerable was written later of the insect, nothing new was learned of its habits until 1885, when Mr. James Fletcher found what he believed to be the half grown larva hibernating under a silken covering on the twigs. In April, 1891, Dr. C. H. Fernald (Bull. No. 12, Mass. Hatch Agr. Expt. Sta.) recorded the results of several years of observation upon the pest. His observations were quite extensive and threw considerable new light upon the life history of the insect. It was not until 1892, however, that the life history of the Bud Moth as observed in New York State and in Canada was correctly, although very briefly, recorded (Mr. James Fletcher's Rept. as Entomologist for Dept. Agr. Canada 1891, p. 195).

Appearance and habits of the insect in the spring.—As the attention of fruit growers will be attracted to this pest by its appearance and methods of work upon the buds in the spring, it seems best to begin the discussion of its life history at this point.

The insect comes from its winter quarters and appears upon the buds in the form of a small dark brown larva about one fourth of an inch in length with a shining black head and thoracic shield. The date of its appearance in this State varies considerably. In 1891, it appeared about April 15; but in 1892 it was about May 7 before any larva began work on the buds at Ithaca, N. Y., and on some late varieties of apples they had not all made their appearance by May 15. As a rule it may be said that they time their appearance by the date of the opening of the buds. Thus the earliness or lateness of the season or of the variety of the tree infested will vary the time from two to four weeks, ranging from April 15 to May 15.

In some cases the larva appears before the bud has opened sufficiently for it to readily enter. It is then forced to eat its way into the bud. Once within the bud it revels in the very tender growing leaves or flower buds, tying them together with its silken threads, and thus forming for itself a well protected nest within which its destructive work goes on (Fig. 4). The larva does not confine its work to one or two leaves or flowers, but it seems to delight in devouring a part of a leaf here or one side of a developing flower there. So that nearly every leaf or flower in the open-



FIG. 4.—Work of larvae in opening buds.

ing bud is forced to contribute to the greed of the little larva, thus greatly increasing its destructiveness.

The larva does the most damaging work upon young trees or upon nursery stock when it attacks, as it often does, the terminal buds of twigs or shoots. Its work in the central portions of the opening bud is quite certain to check the growth of the shoot in that direction. Again, in some cases the larva not only feeds upon the leaves of the bud, but it begins, usually, near the base of the second or third young leaf, and works its way into the pith of the twig. A burrow is thus formed which sometimes extends for two or three inches down the shoot. The entrance to this burrow is more or less concealed by some of the basal

leaflets of the bud which are dead and dry and fastened with silk to one side of the hole. When attacked in this manner, the whole tip of the shoot soon dies back as far as the burrow extends. Thus the symmetry of the growth of the tree is marred, and if in a nursery its market value greatly lessened.

Some larvæ do not leave their winter quarters until the buds are quite well opened. The manner of working of these larvæ, and the later steps in the work of those that appeared earlier, has been well described by Prof. Comstock in the notes of the Department of Agriculture at Washington taken May 14, 1879, while he was U. S. Entomologist. He says: "The larva settles on one of the more advanced leaves, of which it cuts the petiole half through either near its base or close to the leaf so that it wilts. Of this half dead leaf it forms a sort of tube by rolling the edge of one side more or less down and fastening it with silken threads and then lining the inside sparsely with silk. If the leaf which it has selected as its final home should become too weak at the place where it has been cut so that there may be danger of its falling to the ground; then the larva goes to work and either strengthens it with silk which is fastened to the twig and petiole

or ties the apical portion of the tube to another leaf or cuts that part of the leaf which contains its tube from the rest of the leaf, so that either the whole or only that portion which contains the tube hangs suspended from another leaf." The larva lives in this tube most of the time, only coming forth to feed; when disturbed it retreats into the tube out of sight. In feeding it draws other leaves, one after another, toward it and fastens them with threads

of silk, thus forming a nest (Fig. 5). Some of these partially devoured leaves soon turn brown and die, thus rendering the nest quite conspicuous.

After their first appearance in the spring, the larvæ continue to feed, mostly at night, in the opening fruit and leaf and buds for six or seven weeks. During this time, they probably cast their skin three times, but no change takes place in their general appearance except the natural increase in size. The full grown larva is described on page 7. Soon after reaching maturity the larva begins to make preparation for its transformation to the quiescent stage of the insect—the pupa.



FIG. 5.—Work of larvæ among opening leaves.

Pupation.—Within a tube, formed by rolling up one side of a leaf or by bringing together two or three half devoured leaves and securely fastening everything with silken threads, the larva

retreats and lines the interior with a thin closely woven layer of silk. This forms the cocoon of the larva, within which it is soon to undergo its wonderful change to a pupa. In some cases the cocoon is formed on a leaf or twig and covered on the outside with the fine wool taken from the leaves or petioles, thus giving it a close resemblance to its surroundings so that it is not easy to detect it. Those larvæ which emerge first on the earlier varieties of tress attain maturity and begin spinning their cocoons in the latter part of May. The date of pupation varies from June 1st to the 25th in this State. The pupa is described on page 8.

The pupa (Fig. 2 *a* and *b*) lies quietly in its silken chamber for about ten days. It then pushes its head through one end of the cocoon, and by the aid of the rows of the tooth-like processes on its dorsum it works itself along until the greater portion of its body projects from the end of the cocoon. The pupal skin then splits open over the head and along the back and sides, and the delicate little moth emerges.

Habits of the moth.—After crawling forth from the pupal skin and waiting a few minutes for its wings to expand and dry, the moth flies away and is soon ready to begin its mission of the perpetuation of the species. The moths begin to appear as early as June 5 in this State, and all have not emerged by July 10. They are the most active at night. During the day they remain quiet on the trunk and limbs of the tree with the wings folded roof-like over the body. In this position they so closely mimic the bark of the tree as not to be readily seen. The moths lived about two weeks in our cages.

Oviposition.—Three or four days after emerging, the moths copulate and egg-laying begins. Oviposition takes place mostly at night. The eggs are usually laid singly on the under side of the leaves; some were found upon the upper surface and sometimes from two to seven occurred slightly overlapping each other in a cluster. The eggs (Fig. 6) are curious objects. They are disc-like, very much flattened, usually oval in outline, a few are circular, and measure .8 mm. by .7 mm. A flat outer rim .2 mm.



FIG. 6.—Egg showing embryonic larva within, greatly enlarged.

wide adheres closely to the leaf leaving a central slightly elevated rounded disc in which the larva develops. The egg is so nearly transparent that it can be scarcely distinguished from the leaf unless it be held in the right light when the egg will reflect the prismatic colors like a drop of water. In fact the eggs so closely resemble minute drops of water or a fish scale on the leaf that a lens is necessary to determine the egg characters.

Although the eggs were closely watched, no visible changes in color or arrangement of the contents took place until about nine days after they were laid. Then the developing insect was plainly visible as a greenish larva with a dark brown head and thoracic shield. The larva was curled in the central portion of the egg as shown in the figure. Eggs which were laid July 1 and 4 hatched July 11, the egg stage thus lasting from seven to ten days.*

Habits of the larva during the summer.—The larva emerges from the egg through a hole made by it near the edge of the central disc. The little greenish colored creature which emerges is scarcely 1 mm. in length; the thoracic shield is dark brown and its similarly colored head is nearly twice as wide as the body

* These observations upon the eggs of the Bud Moth differ much from those of Dr. Fernald recorded in Bulletin 12, Mass. Hatch Agr. Expt. Station, April, 1891. Dr. Fernald says: "The female lays her eggs, when in confinement, in clusters of from four to ten or eleven, often overlapping each other. They are oval, flattened, four-fifths of a millimeter long, and half as wide, sordid white with a narrow border of clear and transparent white, while the center of the eggs is one complete mass of minute granules. In about three days the center of the egg has grown darker, and the granules larger; and on either side there is a clear, white, oval space about one-third the length of the egg. In about two days more the outer edge of the center is the same color as in the last stage, and inside this is a narrow, lighter band, while in the center is seen the form of a cylindrical larva larger at one end, and both ends slightly curved toward each other; and in one or two days more the whole form of the larva is visible, the head, thoracic and anal shields being black. The egg stage lasts from eight to eleven days."

Our eggs were obtained in large numbers from moths reared from the larvæ and confined in cages containing branches of apple which had been very carefully examined for any other eggs before they were placed in the cages. Dr. Lintner has also called attention to the fact (Can. Ent., XXIII, 231) that the eggs of the Bud Moth which he obtained were very different from those described by Dr. Fernald.

which is sparsely clothed with hairs. It does not stop to eat the shell of its egg, but immediately begins to feed upon the outer layer of cells or epidermis of the leaf, usually upon the under side. A few hours later the larva makes for itself a tube, open at both ends, of silk in which pellets of excrement are intermingled. This tube is usually made alongside the mid-rib of the leaf, but sometimes near a large vein. These tubes are the homes of the larvæ from which they sally forth to feed upon the surrounding tissues and into which they retreat when disturbed. The larvæ further protect themselves by spinning, as they go, a thin layer of silk, in which the natural pubescence of the leaf is mixed, over their feeding grounds. This silken web extends over the tube also and being gradually thickened as the larva grows, the tube is scarcely visible from without. As the larva increases in size and the area over which it feeds becomes larger, the tube is enlarged and lengthened along the mid-rib, sometimes becoming nearly one inch in length. The silken web under which the larva feeds covers the entire field of operations but is so thin near the edges where the larva has last fed as to be scarcely visible. The excrement of the larva being retained by the web appears as little black pellets scattered here and there over the feeding ground.



FIG. 7.—Leaf showing the work of a young larva during the summer. Natural size.

The larvæ feed almost entirely upon one epidermis and the inner tissues of the leaf, leaving the net-work of little veinlets and rarely eating through the opposite epidermis which thus forms the floor of its feeding grounds. The veinlets and epidermis remaining soon

turn brown and die; and as the epidermis is quite transparent the work of the larva is rendered conspicuous from either side of the leaf. Rarely more than one larva works on a leaf. Sometimes two leaves are fastened by the silk of the web, and the larva then works between the leaves feeding mostly on the tissues of one.

The larvæ continue to feed in this manner during July and

August, and some may be found feeding in September. The area over which a larva has fed is very irregular in outline and usually covers less than one-fifth the area of the leaf. It usually extends along both sides of the mid-rib and branches out along the large veins into irregular areas. (Fig. 7.)

From the time the larvæ emerged from the eggs in our cages (July 11) they received careful attention. Some were placed outdoors on a tree under a net; and the food in the cages was kept as fresh as possible and their habits of growth and feeding noted. And although the observations upon their feeding habits as recorded above agree in general with those of Dr. Fernald, there were no such changes took place in the size and appearance of the larvæ as he describes.*

Our observations show that the greenish color of the larva when it first emerges changes in a day or two to a dark brown, slightly lighter than that of the mature larva; and the larva then maintains this brown color throughout its whole existence. The head and thoracic shields change to black, but the anal shield in the early stages of the larva is scarcely to be distinguished from the body color; rarely does a mature larva have the anal shield blackish. The larvæ grow very slowly. Instead of attaining a length of 4 mm. in a week (as did Dr. Fernald's), they did not moult or cast their skin the first time until five days after emerging. They then measured 2.25 mm. in length, and the head was now but little wider than the body. The second moult occurred seven days after the first. There was no change in the appearance of the larvæ except in size, they then measuring 3 mm. in length. July 28, or five days after the second moult, the larvæ

*Dr. Fernald says: "When the young larva hatches it does not eat the shell of its egg, but goes on to the tenderest leaves and almost immediately begins spinning a microscopic layer of silk, under which it eats the outer layer or epidermis of the leaf. The larva is then about three millimeters in length, of a creamy white color, with head, thoracic and anal shields blackish brown, and a few minute pale hairs on the body; the head is very large for the rest of the body. In a week the larva is nearly four millimeters long, light yellowish brown, with the head, thoracic and anal shields dark brown, and it eats minute holes through the leaf, its silken web now being visible to the naked eye. The larva gradually becomes a trifle more brownish, increases in size and enlarges its web along the side of the mid-rib."

cast their skins for the third time, and attained a length of 4 mm.*

After the third moult the larvæ fed but little; one or two moulted the fourth time. When this stage is reached, the larvæ seem to know instinctively that they have reached that point in their development when it is necessary for them to make preparations to go into winter quarters, even though it be several weeks yet before the leaves become unfit for food, or fall from the trees.

Hibernation.—Previous to 1885, the Bud Moth was supposed to pass the winter in the egg state as recorded in 1840 by Schmidberger. In 1885, however, Mr. J. Fletcher in his Report as Entomologist to the Department of Agriculture of Canada says :

*It may be of interest to some to know how it was determined when the larva had moulted, working as it does mostly out of sight. The method employed was that used by Mr. H. G. Dyar who has worked out the number of moults of many species of caterpillars. He found that the diameters of the head of a larva taken after each moult formed a geometrical series. The head being chitinous does not increase in size between the moults. So that by ascertaining the diameter of the head before and after a moult, a ratio could be taken with which the terms of the series could be obtained; or in other words, one could calculate what the diameter of the head of the larva was going to be after any future moult. This method has been found to work surprisingly well in practice here at the Insectary. Mr. Dyar has found but few exceptions in his work. It requires careful measurement with a compound microscope, however, and the real diameters frequently vary from the calculated, but rarely more than .05 mm.

The heads of the Bud Moth larvæ were found to measure .225 mm. when first hatched. In a few days a cast head was found under a web. The diameter of the head of the larva in the tube was .288 mm. From the ratio between these diameters, calculations were made of what the diameters of the heads would be after the other moults. But what would be the last term of the series? It so happened that a larva which had spun its cocoon but had not yet changed to a pupa was available. The diameter of the head of this fully matured larva gave the last term. Surprising as it may seem, the calculated seventh term lacked only .06 mm. of the real diameter of the larva's head. The calculated diameters after the second moult were as follows: .368 mm.; .471 mm.; .603 mm.; .772 mm.; and .99 mm. The real diameters thus far obtained from measuring the heads of the larvæ are: .363 mm.; .43 mm.; .56 mm.; and 1.05 mm.; leaving that after the fifth moult to be determined. The diameters after hatching and after the first moult are not included in these figures. They were obtained by measurement and formed the basis for the others; they were .225 mm. and .288 mm.

"I do not know for certain the life history of this little moth, but believe that it passes the winter on the branches of the apple trees, protected by a covering of silk. I have found small brown larvæ hibernating in this manner at Kentville, N. S. The size of the caterpillar in the spring when it attacks the buds also points to the probability of this view." Prof. Fernald says: "Late in the fall the silken web is quite heavy and thick, and the larva deposits its excrements in little pellets in the form of a tube, under the web, within which it hibernates during the winter." In August, 1891, Dr. Lintner stated (Can. Ent., XXIII, 231) that: "He had believed that eggs were deposited in the month of April by the parent moths, from some imperfect and denuded specimens that had been captured fluttering about the trees at this time, and which seemed to be that species. Some of the larvæ which he had hatched from the eggs in June, had attained such size in early July when they died, that they certainly should have attained full maturity during early autumn." Again in 1892, Mr. Fletcher says in his Report for 1891: "In 1885 I found in Nova Scotia some small larvæ enclosed in silken cells, which they had spun in the roughness of the bark of fruit spurs upon apple trees. Upon one or two occasions last year the method of passing the winter of this insect was discussed at scientific meetings, but there seemed to be doubt about the matter. This winter I have made careful search upon apple trees and upon some twigs, which were sent to me by Dr. Young, bearing the larvæ of a small Coleophora. In every case I have been able to find the larvæ of this (Bud) moth enclosed in small silken cells, covered over with, apparently, the excrement of the caterpillar, so that I am convinced that for this part of Canada and Nova Scotia, this is the usual mode of passing the winter."

From these extracts it will be readily seen that there is considerable difference of opinion in regard to the stage and manner in which this pest passes the winter. Especial attention has been given to this part of its life history here at the Insectary.

During 1891, many observations were made upon the larvæ working upon apple trees on the University grounds. The work of the larvæ in their early stages under their webs upon the leaves progressed as discussed under the habits of the larvæ dur-

ing the summer. By September 15, however, it became apparent that the larvæ were feeding but little, if any, and several of the tubes under the webs did not contain larvæ. By November 1, not a larva could be found in nearly one hundred infested leaves taken from various parts of the trees. What had become of the larvæ? By very close scrutiny of the twigs which bore infested leaves, it was found that in almost every case there was a small brown larva snugly ensconced in a little silken cell made in some angular roughness of the bark. These larvæ could not be distinguished from those which had been in the tubes only a few days before.

To leave no room for doubt that these were the larvæ of the Bud Moth, several twigs were enclosed in nets. These larvæ did not leave their silken cases or hibernacula until about May 15, 1892. Their work during May and June was similar to that of Bud Moth larvæ on other trees. July 5, 1892, some of these larvæ had pupated, and the moths emerged July 15. They were typical *Tmetocera ocellana*, thus proving that the larvæ which were found in the silken hibernacula were those of the Bud Moth. These observations also go to show that the larvæ do not hibernate in their tubes upon the leaves where Dr. Fernald left them in the fall.

In 1891, we also had a similar experience to that recorded by Dr. Lintner above. Larvæ which hatched in the latter part of June, attained such a growth by July 20, that it seemed as if they must become full grown before fall. All had disappeared, however, by August 1, and were supposed to have died.

Further observations were made upon this point in 1892. The eggs obtained from moths confined in cages hatched July 11; and the larvæ were given every chance to grow in our cages and on trees in the field. These larvæ had moulted the third time by July 28, after which they fed but very little. On August 2, one of the larvæ in the cage had left its tube and leaf. It was found in a minute, closely woven, silken case constructed in a slight groove by the larva in the bark of the twig; the bark presenting no angular places, the larva had cut one. The outside of the cocoon was completely covered with little particles of bark and dirt, thus rendering it a very inconspicuous object. These hiber-

nacula are but little more than an eighth of an inch in length and just large enough to hold the somewhat contracted body of the little larva. They are always made on the twigs and smaller



FIG. 8.—Twig showing the position of the winter homes of the larvae at *a*, *a*, and *b*, natural size.

branches, and usually quite near a bud. Figure 8 represents a twig natural size bearing three hibernacula at *a* and *b*. By the middle of August most of the larvæ both in the cages and in the field had gone into hibernation. Frequently the hibernacula

were made under some convenient piece of dead leaf or bud scale (*b*, Fig. 9) which had happened to lodge on the bark of the tree. The bit of leaf or scale would be firmly fastened to the branch by the silken case underneath. Some of the larvæ which were of the same brood as those which went into hibernation early in August, did not leave their tubes until September 1. But none remained in the tubes when the leaves fell in autumn.

These observations leave but little doubt that the larvae cease feeding on the leaves soon after the third moult; a few may moult the fourth time, and some of them immediately go into hibernation while others wait until later, but none remain upon the leaves during the winter. Undoubtedly those larvae which pass the third or fourth moult quite early in the season, go into hibernation, even though the leaves remain green and do not fall for two or three months afterward.

The little creatures seem to understand when they have reached the hibernating stage. And notwithstanding the temptation of plenty of food and weeks of mild weather, they do not believe in waiting for their comrades who from unforeseen circumstances have not reached this eventful period in their lives; thus all can pass the winter under the same conditions and start equal in the spring.

In the light of these facts it seems very probable that the larvæ which we had under observation in 1891, and those upon which Dr. Lintner based his records as mentioned above, had reached

their hibernating stage, and either escaped our observation in their hibernacula or they may have died in seeking a suitable place to hibernate.

Taking into consideration all of these observations, we cannot escape the conclusion that the normal method of hibernation for the Bud Moth in New York State, Canada, and Nova Scotia is as a half grown larva snugly hidden in a silken case on the twigs of the tree. In this position it is right at hand to nip the bud upon its first showing signs of opening. Whereas, if the little larva fell to the ground with the leaf, it must of necessity proceed by a tortuous and very uncertain route over the ground and up the tree to the buds. It would seem that instinctively the little creature must choose the former method.

It has seemed best to discuss the hibernation of this insect in such detail not only because of the widely differing opinions held, but because it has a very practical bearing which will be discussed under the preventive methods to be used against this pest.

When spring opens, the little brown larvæ leave their winter homes and begin their destructive work upon the buds as described under the appearance and habits of the larvæ in the spring; and thus the yearly life cycle of the insect is completed.

Number of Broods.—The pest is normally single brooded in this and more northern latitudes. The moth appears and lays her eggs in June and July; the larvæ feed upon the leaves until half grown and then hibernate in that stage. Farther south in the vicinity of Washington, D. C., it is possible that there are two broods. Prof. Comstock's notes taken there in 1879, show that the larvæ pupated as early as May 19, and moths began emerging May 29. If there are two broods there it would be interesting to know the habits of the larvæ during the summer.

In his Seventh Report (1891), Dr. Lintner speaks of a second brood of larvæ working on the leaves during July. This is misleading, for these larvæ are simply the early stages of the same brood of larvæ which will appear upon the buds the next spring. There is only one brood a year, but the larval period extending over a part of two years causes the larvæ of two different broods to appear during the same calendar year.

NATURAL ENEMIES OF THE PEST.

This pest, like many of our insect foes, has its natural enemies which help to hold it in check. There are several parasitic insects belonging to the Hymenoptera which prey upon the larvæ of the Bud Moth. They are all active wasp-like insects, scarcely one-fourth of an inch in length.

Taschenberg records the following five species of parasites as preying upon the insect in Europe: *Chelonus nigrinus* and *similis*, *Microdus rufipes*, *Mesochorus dilutus*, and *Lissonota culiciformis*.

In this country, but three species seem to be at work upon the pest. Dr. Fernald says (Bull. 12 Mass. Hatch Agr. Expt. Sta., 1891): "Some years ago I found a most curious parasite attacking the larvæ of this species. It was a Hymenopterous insect of a pea green color, and was attached to the top and across the second segment of the larva, on the outside and entirely out of the way of harm; there it grew fat at the expense of its host which died a lingering death. The parasite was determined for me by Mr. E. T. Cresson as *Phytodictus vulgaris* Cr." In July, 1892, we reared two species of these small Hymenoptera from the larvæ of the Bud Moth. Dr. Riley says of them: "One of them proves to be a *Pimpla* near *P. alboricta* Cr., the main difference being in the color of the clypeus. It is not likely that it is an undescribed species and may prove to be one of the forms described by Provancher. The other is *Microdus laticinctus* Cr." *Microdus laticinctus* seems to be quite a common parasite, as Dr. Riley bred it from larvæ received from Canada in 1870, and again in 1879 at Washington, D. C. Prof. A. J. Cook says (An. Rept. Mich. Agr. Expt. Sta., 1891): "We reared from the Bud Moth, the parasite *Microdus laticinctus* which is very common, and will surely do much to stay the ravages of this pest."

Besides these parasitic enemies, the Bud Moth has a predaceous insect foe in the form of one of the large wasps, *Odynerus catskillensis*. This wasp builds mud nests or cells in angular places about houses. In each cell it deposits an egg and then goes on a foraging expedition to get food with which to store the cell. This food often consists of caterpillars which are paralyzed but not killed, by the wasp, and thus furnish a very delicious morsel for

the grub when it hatches from the egg. In June, 1892, a cell of this wasp was found which contained six nearly full grown larvæ of the Bud Moth, and a smaller green larva. About the same time a correspondent wrote that he saw a wasp pick a brown larva out of a cluster of leaves on a quince tree; doubtless it was a Bud Moth larva.

Not only is this pest attacked by foes among its own kind but the birds also seem to take a part in its destruction. Mr. J. Fletcher in his Report for 1885, quotes from Rev. J. R. Hart, of Bridgetown, N. S., as follows: "Two years ago our apple trees were attacked by a large number of brown grubs which ate the young leaves and fruit buds just as they were opening. I tried to watch them developing, but the birds so industriously gathered them up that I could find none coming to maturity."

Doubtless all of these foes aid considerably in keeping the pest in check, but it has now become so numerous and wide spread that its enemies are insufficient and the devices of man must be called into action.

METHODS OF PREVENTING THE RAVAGES OF THIS PEST.

Previous to 1887, the principal method recommended to prevent the ravages of this pest was to hand-pick and destroy the nests containing the larvæ or pupæ in the spring. The nests are rendered quite conspicuous at this time by the dead brown leaves in them. This of course is the surest method to prevent the further increase of the pest. But by the time the work of the larvæ has progressed far enough to render its nest conspicuous, the insect has done its worst damage; the growth of the shoot has been checked, or if a fruit bud most of the flowers are destroyed. The most serious objection to this method, however, is that it is impracticable on a large scale. On a few small choice trees it could be done profitably. But the pest must not be allowed to get such a foothold upon the developing foliage and blossoms. Fruit growers cannot afford to wait until after the developing fruit and new growth are "nipped in the bud" before placing any obstacles in the way of this depredator.

The principal aim and end had in view in all the observations made upon the pest here at the Insectory during the past two

years has been to find just what obstacle could be used to check the insect before its most destructive period was reached ; and especially at just what period the obstacle could be presented the most effectively.

In the adult stage, as a moth, the pest does no damage to the fruit or trees. It feeds but little, if any, during its short lifetime of two or three weeks. But if it could be destroyed before it had performed its mission of laying eggs to perpetuate the species it would be then worth while to try. The principal method recommended to destroy moths is by trapping them with lights. Perhaps many of the moths could be thus attracted by placing lights in an orchard, but it has been our experience that the number taken would not repay for the trouble ; and besides most of them that were caught would be males. Thus it is not practicable to combat the pest while in the adult stage.

The eggs laid in June and July are freely exposed upon the under surface of the leaves, and would seem to offer a good chance for the application of some insecticide. But what can one apply that would kill the egg and not the leaf? In 1891 (Can. Ent., xxiii, 231) Dr. Lintner said he thought the egg could be killed by kerosene emulsion. Our experience with the eggs of the Pear Psylla (*Psylla pyricola*) in 1892, and with those of the Apple Aphis (*Aphis mali*) in January, 1893, show that the eggs of some insects at least are almost impervious to any of the insecticides thus far employed—even undiluted kerosene was of no avail. If an effective insecticide was found, it would be hard to get it upon the eggs as they are usually scattered about upon the underside of the leaves. No experiments have been tried to destroy the eggs of the Bud Moth ; but in the present state of our knowledge of the efficacy of insecticides against the eggs of insects, it will not be practicable to try to combat the pest in this stage.

Following the development of the insect, the next stage in its life history which presents itself is that of the young larva as it works upon the leaves in July and August. Preliminary observations upon the pest while feeding at this time apparently exposed upon the leaves, had led us to hope that it might be easily checked by the application of an arsenical spray. Further detailed observations, however, showed that the larva feeds over but a small portion of the leaf usually upon the under side ; and it not only

spends most of its time in its tube, but when it does sally forth to feed, it is protected by a layer of silk which it spins and underneath which it works. Owing to the protection afforded by the tube and web, the larva could not be readily reached by any insecticide which kills by contact, as kerosene emulsion. The only chance then to reach the pest in this stage seems to be to get some poisonous insecticide upon the leaves just about the time the larvæ are beginning their work; so that as they extend their feeding grounds they must get some of the poison. This will prove rather a difficult thing to do in practice for several reasons. The poison must be applied to the underside of the leaves. It will need two or three applications to catch the earliest and latest larvæ which emerge. And on early varieties it is not advisable to spray the trees within at least a month of the time for picking the fruit. Thus it would seem to be hardly profitable to spray in July and August for this pest alone.

Undoubtedly some of the larvæ could be destroyed by the spray, using Paris Green at the rate of one pound to two hundred gallons of water, and if fruit growers are spraying for fungus diseases like the Apple Scab (*Fusicladium dendriticum*) or for a leaf eating insect like the Fall Web Worm (*Hyphantria cunea*), they should spray as late as July 15. And as Bordeaux Mixture, the fungicide most commonly used, can be readily combined with Paris Green without decreasing the effectiveness of either, it would be advisable and profitable under these conditions to spray the trees in July with this combination for fungi and the young larvæ of the Bud Moth. It would cost but little more, and the Paris Green could be used at the rate of one pound to one hundred and fifty gallons in connection with the lime in the Bordeaux Mixture. This plan is practicable and if given a fair trial we believe that it will so lessen the numbers of the pest that the application can be profitably made.

In Massachusetts, according to the observations of Dr. Fernald already quoted, the young larvæ fall to the ground with the leaves. Therefore he says: "To destroy these caterpillars it is desirable to gather all the leaves from under the infested trees in the fall and burn them." Other recent writers following Dr. Fernald, have advised the same treatment. Our observations here at the Insectary corroborated by those of Mr. Fletcher in Canada

show that this gathering and burning of the leaves would be useless labor so far as combating the Bud Moth is concerned. For the larvæ are not on the leaves when they fall, but are snugly hidden on the twigs where they will be right at hand when the buds open. Of course, the burning of the leaves and other rubbish in an orchard is desirable under any circumstances, for these harbor many other injurious insects, but one cannot hope to check in the least the ravages of the Bud Moth by this means.

The next question which presents itself, as one follows the life history of the pest is, can it be reached under the silken covering on the twigs in the winter? No experiments have been tried here at the Insectary to reach the pest in this stage. Mr. James Fletcher, however, in his Report as Entomologist to the Department of Agriculture of Canada for 1891, says: "Kerosene emulsion sprayed three times over trees, upon the twigs of which they were in winter quarters inside their silken tubes, had no effect upon the larvæ, having failed apparently to penetrate through the silken covering." And judging from the closely woven and comparatively thick covering over the larva, no insecticide that would not injure the tree would penetrate the covering. Undiluted kerosene might, but we have found that it severely injures the previous year's growth on apple and peach trees. Thus there seems to be no hope of reaching the insect while it is in hibernation.

Thus far in the discussion of the preventive methods which can be used against this pest, the conclusions reached have not been as encouraging as we had hoped to be able to present when the study of the insect was begun. However, we have now reached that point in following the life history of the pest where we confidently believe it can be easily and successfully combated. This point is where the little half grown larva comes from its winter quarters and begins feeding in the spring upon the opening buds. We have only to manage it so that the little larva's first meal in the spring will be a poisonous one. This is the way the Codlin Moth is so successfully kept in check; the little larva which hatches in the blossom end of the developing apple finds a tiny bit of poison served up for its first meal by the deft hand of the spraying machine. In a similar manner, if one can manage to have a little poison on the opening buds when the larva of the Bud Moth appears, the little creature can be effectually destroyed

before it can do much harm. This can be easily and cheaply accomplished by spraying the trees with an arsenite.

When and with what shall we spray? Fruit growers usually do not begin to spray their trees until the blossoms have fallen. Recent investigations, however, have shown that the best results are obtained in fighting fungus diseases when the spraying is begun earlier. So that fruit growers are now being advised to spray their trees once or twice before the flowers open with a fungicide for the Apple Scab and other kindred fungus diseases. Again, if fruit growers wait until the blossoms have fallen—the time to spray for the Codlin Moth—before spraying with an arsenite, the Bud Moth will have done the greater part of its damage. Thus fruit growers must begin to spray earlier than usual both for fungus diseases and for insect pests. And as the insecticide can be combined with the fungicide and applied at the same time, the extra expense of one or two sprayings before the blossoms open will be more than met by the extra vigor and growth of the tree and the increased numbers and selling qualities of the fruit. Experiments have shown that it pays to spray for the fungus diseases alone at this time; and we believe that this is the time when the Bud Moth can be the most easily, cheaply, and successfully combated.

The Bordeaux Mixture* is the best fungicide to use in combination with the arsenite. And Paris Green seems to work better than the London Purple or White Arsenic with the mixture. The Paris Green also has some fungicidal properties, and the effective-

* To make the Bordeaux Mixture, dissolve six pounds of Sulphate of Copper in four or five gallons of hot water. Slake four pounds of quick lime in sufficient water to form a thin whitewash and strain this through a gunny sack (burlap) into the copper sulphate solution. Dilute to forty gallons with water, and the mixture is ready for use. When using, it must be kept thoroughly stirred to keep the lime in suspension. The preparation of the mixture in large quantities may be simplified by a test which obviates the necessity of weighing the lime. Keep the mixture thoroughly stirred when the thin whitewash of slaked lime is being poured through the burlap, and add from time to time a drop or two of the commercial potassium ferrocyanide to the mixture. If not enough lime has been added the drop of ferrocyanide will turn to a very dark color the moment it touches the mixture; when enough lime has been added, the ferrocyanide will not change color when it is dropped into the mixture.

ness of either the insecticide or fungicide is not decreased by combining them. Therefore we would advise fruit growers to spray their trees with the Bordeaux Mixture and Paris Green combined, using the arsenite at the rate of one pound to two hundred gallons of the mixture.

If one thinks that he cannot afford to apply but one of the substances, use the Paris Green ; for it is primarily an insecticide and also has considerable fungicidal properties, while the Bordeaux Mixture is purely a fungicide and practically useless as an insecticide. In case the Paris Green were used alone, it would not be advisable to use it stronger than one pound to two hundred and fifty or three hundred gallons of water, as it would probably injure the tender opening buds if stronger. The lime in the Bordeaux Mixture forms an insoluble compound with the injurious soluble arsenic in the Paris Green and thus allows a much larger quantity of the arsenite to be used in connection with the Mixture. It is not safe to mix the arsenites with a fungicide containing ammonia and no lime, as the ammonia dissolves the arsenic, thus making it very injurious to foliage.

The time to spray will depend upon the climatic conditions and upon the variety of the tree. The first application should be made just as the buds are opening in the spring. In 1892, the buds upon early varieties began to open about April 15, and the larvæ appeared soon afterward. On later varieties the buds were ten days later in opening. So that ordinarily the first spraying should be done about April 15 in this latitude. It will no doubt vary a week or ten days in different sections of the State. A gallon of the Mixture will spray a large tree at this time as there is but little foliage. A second spraying should be made about a week or ten days later or before the blossoms open. If these two applications be thoroughly made, we believe that the pest will be so greatly checked as to render any further spraying for it alone unnecessary.

Do not spray when the trees are in bloom. If the trees are not sprayed when the buds are opening and the pest thus allowed to get a start, it may pay to spray the trees later, even when the larvæ are protected in their nests. Mr. J. Fletcher says (Rept. for 1891): " Although like the Leaf-rollers they enclose themselves in cases made of leaves drawn together, they

have to continually draw in fresh material, and I found last season that where an orchard was severely attacked at the same time by this insect, the Canker worm (*Anisopteryx pometaria*.) the Lesser Apple Leaf Roller (*Teras malivorana*), and the Oblique-banded Leaf-roller (*Cacaecia rosaceana*), all were much reduced in numbers by a single spraying with Paris Green."

We have not had an opportunity to try any extensive experiments in spraying for this pest early in the spring. However, in the spring of 1892, four trees on which there were several larvæ in hibernation were sprayed the first time April 15. Owing to frequent hard showers, it was almost impossible to keep any of the poison on the opening buds. By May 15, the trees had been sprayed five times, using one pound of Paris Green to from one hundred and fifty to two hundred gallons of water. This excessive spraying resulted in considerable injury to the leaves and flowers. But enough of the larvæ were killed to lead us to believe that in an ordinary season the treatment recommended above will prove sufficient to prevent the pest from doing serious damage. In spraying large trees it will be necessary to have one of the Barrel Spraying Machines. Use as fine a spray as possible.

To summarize, it is not practicable to try to check this pest in either the adult or egg stages, or while it is in hibernation as a half grown larva. Undoubtedly it can be checked somewhat by spraying in July when the larvæ are at work on the under side of the leaves. But the best time to combat the pest the most profitably and successfully is in the spring when a little poison can be easily sprayed upon the opening buds; and thus the little larva, hungry from its long winter's fast, will be quite certain to get the fatal dose at its first meal.

MARK VERNON SLINGERLAND.

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Cornell University Agricultural Experiment Station.

HORTICULTURAL DIVISION.

FOUR NEW TYPES OF FRUITS.

**Prunus Simonii,
Crandall Currant,**

**Wineberry,
Dwarf Juneberry.**



By L. H. BAILEY.

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BULLETINS OF 1893.

50. The Bud Moth.
51. Four New Types of Fruits.

FOUR NEW TYPES OF FRUITS.

New types of fruits are nearly always misjudged. They are compared with the most similar type of well-known fruit, even though the two may be very unlike. It should be remembered that wholly new types of fruits are not to be measured by existing standards. They are not introduced, as a rule, for the purpose of supplanting other fruits but with the intent that they shall add variety to our fruit-lists, and occupy places which are now vacant. If they fill an unsupplied demand or if they create a new demand, then they may be counted successful. It is often said of the Crandall currant, for instance, that it can never supplant the common currants and is therefore worthless. It is true that it can not compete with our present currants, but it may fill a place in the market or in the home demand which no other fruit fills; if so, it is worthy, and we shall grow it at the same time that we increase the plantations of red and white currants. The following new types must ultimately stand or fall upon their own intrinsic characters.

It must also be said that new types of fruits and vegetables usually suffer from injudicious praise. Their merits are so much exaggerated that great disappointment results when the varieties come to be known, even though they really possess commendable features. Catalogue descriptions are so often overdrawn and colored beyond the point of belief, that they create a presumption against the novelty in question in the minds of intelligent persons. Novelties are often short-lived because of this disappointment which follows excessive praise; while if the same varieties had been introduced quietly and with candid descriptions, they might persist and eventually become acquisitions to our horticulture. Few fruits have suffered more from this unwise applause than the four which I am about to discuss, and I feel that I must create a wholly new basis of criticism before I can command the attention of careful men.

SIMON OR APRICOT PLUM.—*PRUNUS SIMONII*.*

Something like a dozen years ago, this fruit began to be talked about in North America, although it did not gain any notoriety until six or seven years ago.† It had been introduced from France, where it was first described under its present name and with an admirable colored plate in 1872, by Carrière, in the *Revue Horticole*. I do not know when the fruit reached Europe, but it could not have been introduced long prior to 1872. It was named for Eugene Simon, who sent pits to the Paris Museum while he was representing the French government in China. It is probably native to China, although Hemsley, in his recent *Flora of China*, does not mention it; but this author evidently adopts Maximowicz's opinion that it is indistinguishable from the nectarine and does not regard it worth distinct discussion. It was disseminated by Simon Brothers at Metz, in Alsace, and by Thibaut & Keteleer, at Sceaux, France.

Prunus Simonii began to fruit in this country about 1885 or 1886. I fruited it in 1886.‡ The fruit was also figured and described in the *The Rural New-Yorker* in October, 1886. The fruit, which is shown about three-fourths size in the engraving, is flattened longitudinally, marked with a deep stem cavity and a very prominent suture, and is borne upon a very short stem. The color is very intense and striking, being a glowing dark red slightly mottled with lighter shades. The flesh is yellow, hard, and clings tightly to the somewhat apricot-like pit. The flavor in all the specimens which I have tasted is very disagreeable, being mawkish bitter, and leaving a pronounced bitter almond taste in the

**Prunus Simonii*, Carrière, *Rev. Hort.* xliv. 111 (1872). *Persica Simonii*, Decaisne, *Fruit. du Museum*, vii. 43 (1872-5).

† The first record which I find of *Prunus Simonii* in America is a statement in *Gardener's Monthly* in 1881 (Vol. xxiii. 314) that "under this name Professor Bessey has a peculiar peach-like species, which has been found quite hardy in the college grounds at Ames, Iowa." Both Professor Bessey and Professor Budd disclaim having had the tree at Ames at that date. Professor Budd writes me: "I first saw the tree in bearing in the valley of the Moselle in 1882. We introduced trees from Metz, Germany, in the spring of 1883. Its main defect is its very early blossoming and the fragile character of the flower."

‡ See *Amer. Gard.* vii. 330.

mouth. I have never tried a specimen which I could say was edible, and this is an unwilling confession because the fruit is exceedingly attractive to look upon. Other persons appear to have had pleasanter experience with these fruits for I occasionally read of favorable or at least only indifferent comments upon their quality. But it is certainly true that *Prunus Simonii* is not a delectable fruit in New York. It is said that this bitterness passes away in cooking, although my experience in this direction has not been reassuring.

But there are other demerits in this plant besides its mawkish-bitter fruits. It is not a productive tree so far as I have observed, and I have seen it in many different plantations. It bears young, but the fruiting is not profuse. Many of the fruits are borne upon spurs upon the old wood, and they are often found well down to the base of the leaf-bearing portions of the top.

The two transcendent merits of the fruit of *Prunus Simonii* are the very handsome shape and color, and its long keeping qualities consequent upon its hard flesh. Ripe fruits will ordinarily keep a week or ten days in good condition. And aside from these merits, the tree appears to be as hardy as the common plums. But it blooms early and is often caught by late frosts. Professor Budd recently speaks of it as follows in Iowa: "Fruit large to very large, red in color, and is shaped much like a smooth tomato. Its fault is in the way of too early blossoming. It will pay to grow this fine fruit by laying down in winter, as recommended for the peach. This tree is not fully hardy at Ames without winter protection.*

The fruit of *Prunus Simonii* ripens with the early peaches. In New York it ripens about with the Early Rivers peach. The specimens which are shown in the accompanying engraving were ripe August 24th, 1892. They grew upon heavy soil in western New York. The fruit often drops before it is fully ripe and it frequently rots on the tree. Although it is apparently less liable to attacks of curculio than peaches and plums, it is not exempt from such injury, as it is often said to be.

Prunus Simonii is a wholly distinct species from any other stone fruit. It is not a hybrid between the plum and apricot, as

* Exp. with New Orchard Fruits, etc., 23, in Bull. 19, Iowa Exp. Sta. (1892).

some have supposed. Botanically, it probably belongs in the peach section of the genus *Prunus*, although it is more plum than peach in character of fruit and habit of tree. Maximowicz, a renowned Russian botanist who has given much attention to the celestial floras, has said* that it is identical with the nectarine, but he certainly could not have had a personal acquaintance with the plant. The flowers are shown upon the title page of this bulletin. The two sprigs at the right show the flowers as they appear in Maryland, being sessile and coming out sometime ahead of the leaves. The left-hand sprigs show the stalked flowers opening with the starting of the leaves, as they appear in New York. This difference in behavior of flowers is different latitudes has been mentioned in my plum bulletin (Bull. 38, pp. 22, 30, 31, 37) and it is now under investigation. *Prunus Simonii* grows well upon plum stocks, upon which it is probably oftenest worked in the north. It also takes upon the peach, and upon the Myrobalan and Marianna plums.

After some years of study of this fruit, I am forced to conclude that it is worthless for orchard cultivation in New York.†

* Bull. Acad. Sci. St. Petersburg, xi. 669 (1883)

†The Simon plum appears to be successful in California. The *California Fruit Grower* (Aug. 27, 1892) comments upon its ready sale in the eastern markets and says it "has taken a leading position throughout the season." I. H. Thomas speaks of it in Wickson's *California Fruits* (p. 344) as "large, six and a quarter to seven inches in circumference; flesh firm, rich, sweet, aromatic, delicious, with marked pineapple and faint banana flavors." I find reports of auction sales of California plums to run per box (20 lbs.) as follows: Chicago: July 2, 1892. Cherry plum, \$2; Peach plum, \$1.30 and \$3.75; Simon, \$5.50.

July 8. Cherry plum, \$1.80; Peach plum \$2.50 and \$3.30; Duane Purple, \$3; Simon, \$5.75.

July 12. Duane Purple, \$2.05 and \$2.65; Washington, \$3.25; Cherry, \$2.35; Peach, \$1 and \$3.15; Simon, \$2 and \$5.

New York: July 2. St. Catharine, \$3; Peach plum, \$3.45; Royal Hative, \$2.05 and \$2.55; St. Catharine, \$2.65 and \$2.70; Peach \$2.80 and \$3.10; Simon, \$4.90.

July 5. Cherry plum, \$1.10 and \$1.15; Royal Hative, \$2.05 and \$2.55; St. Catharine, \$2 65; and \$2.70; Peach, \$2.80 and \$2.10; Simon, \$4.90.

July 9. Japan plums, \$2.85 and \$2.95; Duane Purple, \$2.10 @ \$2.40; Peach, 2.30 and \$2.60; Simon, \$4.

It is possible that hybrids between [this and the peach or other fruits may possess commercial merit. If hybrids could be obtained with the peach, they might be expected to be hardier than the peach. As an ornamental tree, *Prunus Simonii* has distinct merit, its erect poplar-like habit, interesting conduplicate leaves, early flowers and glowing fruits making it a conspicuous object.

WINEBERRY.—RUBUS PHŒNICOLASIUS.*

In 1887, Professor C. C. Georgeson, travelling in Japan, sent seeds of this raspberry, collected from wild bushes, to J. T. Lovett Little Silver, N. J. In 1889, Mr. Lovett sold the resulting stock to John Lewis Childs who introduced the plant in 1890 as Japanese Wineberry.† Professor Georgeson describes the wild berries as "of good size, firm and handsome." "When the sepals [or burr] first open the berry is white, but in two or three days it turns bright red, when it becomes sweet and delicious, with a flavor something between the common red raspberry and the black cap." "It is not cultivated by the Japanese, but they gather the berries wherever found." A berry which possesses such decided merits in a wild state may be expected to yield good varieties under cultivation, but one cannot expect that a miscellaneous batch of seedlings thrown upon the market will present uniform value. The current number of the *Mayflower*, published by John Lewis Childs, contains an unsigned article recommending propagation by seed as the best method of multiplying the Wineberry. Mr. Childs' 1893 catalogue contains the same advice, although it also says that the plant is propagated by means

July 7. Cherry plum, \$1.65 and \$2.50; Peach p'um \$3.80 and \$4.15; Simon, \$5.

Boston: July 2. St. Catharine, \$2.37½ and \$5; Royal Hative, \$2.50 and \$3.75; Cherry, \$2.75; Simon, \$7.25.

Whether these remarkable sales are due to the mere novelty of the fruit and its taking appearance, or to its intrinsic merits, I am unable to say. It is said that *Prunus Simonii* loves a dry hot climate, and this may account for its good behavior in California.

**Rubus phœnicolasius*, Maximowicz, Bull. Acad. Sci. St. Petersburg, viii. 393 (1872). Bot. Mag. t. 6479 (1880).

† See *Amer. Gard.* xii. 204 (1891).

of "tips." If the plant is inclined to be variable, this advice is unsafe for the propagation of the plant for fruit; and if the plant is not variable, it has little value for fruit judging from our experience. This *Mayflower* article says that "there is probably no small fruit so eminently desirable and satisfactory for the family garden as the Wineberry."* The 1893 catalogue of Mr. Childs says that the Wineberry "is the most desirable, hardy and profitable small fruit for any climate or soil." The flavor is "very sprightly, sweet and juicy, having no disagreeable sour, but a delicate and luscious flavor peculiar to itself, and superior to other berries." "It is the most prolific berry known, the bushes being literally covered with its large clusters of luscious fruit which are very easily gathered. Owing to their novelty, superb flavor and great beauty they sell more readily and at far better prices than any other berry."

The accompanying illustration is from a photograph three fourths natural size made from the wineberry on our grounds last summer. The plants were received from Mr. Childs in 1890. The photograph was taken August 25, although the fruit began to ripen sometime before this date. The fruits were very small—as raspberries go—and the pips were so little connected that the fruit crumbled when picked. The fruit was cherry red, acrid, with little pronounced flavor. It had little either in size, appearance or quality to recommend it. Whether all wineberries are like ours, I do not know. It is to be expected that considerable variation will be found among them, if they are grown from seeds, as I have already suggested.

H. E. VanDeman, United States Pomologist, reports as follows upon wineberry fruits received from Harper's Ferry, W. Va.: "Berry round, drupes small, deep red, glossy; seeds small, smooth, easily crushed; a handsome berry of medium size and fairly firm; flavor subacid, somewhat sprightly, pleasant. More ornamental than useful." The plant has aroused considerable comment in England and a portrait of it was given in the *Gardeners' Chronicle*, Sept. 18, 1886; but it is always recommended as an ornamental plant, and never for fruit, so far as I have seen.

If our wineberry gives little promise for fruit, the plants never-

* *Mayflower*, ix, 81.



Simon or Apricot Plum.—Prunus Simonii.



Wineberry.—*Rubus phænicolasius*.

theless possess decided merit for certain kinds of ornamental planting. The bristly red canes and rich leaves with felt-white color beneath, render the plant very striking; and the bright little fruits remind one of fragile coral beads sprinkled over the plant. These fruits are at first enclosed in the burr-like calyx, and this covering is thought to afford the plants a distinct value in keeping insects from the fruit. "The hairy, viscous calyx, which covers the berry till it is full grown, effectually repels all insects," Professor Georgeson writes. This may be true; but if the fruit were to develop to the point of commercial usefulness, burrowing insects would undoubtedly find this dense calyx to be an excellent protection from outside attacks. The plant is about as hardy as the common raspberries here, although it failed to endure the winters at Kew, England (near London).*

This interesting plant was first clearly described in 1872, by the Russian botanist, Maximowicz. He reported it as growing in Yezo and Nippon, Japan. A plant of it was sent to Kew in 1875, from the Jardin des Plantes, Paris, and from this Sir J. D. Hooker described the species, with an illustration, in the *Botanical Magazine*, in 1880. Hooker characterized it as "a singularly handsome bramble," and said that the fruit, "though eatable, is mawkish." It was early introduced into this country under its proper name of *Rubus phenicolasius* (the specific name meaning "purple-red hairy"), and was sold by Ellwanger & Barry in 1881. I also received seeds of it from the orient four or five years ago. P. J. Berckmans, President of the American Pomological Society, speaking of the wineberry as having been figured in 1877, adds that it "was known in Holland for a generation before, and cultivated simply as a curiosity in many gardens, the fruit being devoid of any value. Still the new comer may be a form of the well-known sort with better fruit, and if so I will watch it with some interest, as I had known it for nearly fifty years."† I have grown the plants sold by Ellwanger & Barry by the side of the Wineberry from Childs, and they are both *Rubus phenicolasius*. E. S. Carman has been able to cross this plant with "both the blackberry and the rose."‡

* W. Watson in *Garden and Forest*, v. 66 (1892).

† Quoted in *American Gardening*, xiv. 246 (Apr. 1893).

‡ Proc. 6th Conv. Soc. Am. Fl. 92 (1890).

Although I find no fruit with commercial value in our wineberry plants, I am nevertheless ready to believe that the species may eventually give us fruit of considerable value ; but for the present I should class it among the ornamentals rather than among the fruits.

CRANDALL CURRANT.—*RIBES AUREUM*.*



Good and poor types of the Crandall Currant.

The Crandall currant was named for R. W. Crandall, of Newton, Kansas, who found it growing wild. It was introduced in the spring of 1888, by Frank Ford & Son, Ravenna, Ohio. We bought 50 plants of Mr. Ford in 1888, and set them in a continuous row upon high gravelly soil. I have given close attention to the plant since that time and have made two or three reports upon it.†

**Ribes aureum*, Pursh, Fl. Am. Sept. 164 (1814). *R. fragrans*, Loddiges, Bot. Cat. t. 1533.

† See *Amer. Gard.* x. 309 (1889). Bull. xv. Cornell Exp. Sta. 207 (1889). *Annals of Horticulture* for 1891, 52.

This type or species of currant undoubtedly has great promise as the parent of a new and valuable race of small fruit. The Crandall, however, is too variable to be reliable. I early noticed that comparatively few of our plants produce abundantly of large fruits, while many of them bear fruits little larger than occasional plants of the common flowering currant, to which species the Crandall belongs. When the crop was at its height last year (July 26, 1892) I made a record of the size of fruit upon each plant, classifying it into three categories—poor, fairly good, and good. The poor fruit was such as appeared to be little larger than the fruit of the flowering currant, or such as is shown—five-eighths natural size—in the lower spray in the engraving. The good fruit is represented in the upper spray in the engraving, and it ran from five-eighths to three-fourths inch in diameter. The fairly good fruits were those of intermediate size. In order to show that soil did not cause these differences, I transfer the consecutive record of the plants beginning with the end of the row :

6	plants, poor
1	" good
7	" poor
2	" fairly good
2	" good
2	" poor
1	" good
2	" poor
3	" good
1	" poor
6	" fairly good
4	" poor
2	" fairly good
2	" poor
1	" good
1	" poor
2	" good
1	" fairly good
2	" poor
2	" good

 50

27 poor ; 11 fairly good ; 12 good.

Only a dozen plants, or less than a fourth of the whole number, could be called profitable. There is every reason to expect

that if cuttings were taken from these plants alone, the Crandall currant would soon rise in popular estimation. At its best, the Crandall has decided merits. The fruits are large and handsome, firm, of good culinary quality, and the plant is thrifty, hardy and productive. The fruits are borne in very short and open clusters, to be sure, but they are not picked by the cluster like the red and white currants, but singly like the gooseberries. To some people the flavor of the fruit is disagreeable and it has been called a medicinal flavor; but there are others—the writer included—who are fond of them, even to eat from the hand. In pies and jellies we have found them to be useful. It is not to be expected, of course, that these fruits will find a ready market, because consumers are not acquainted with them; but if the stock were more uniform, I think that the Crandall could be recommended as a good fruit for home consumption. There are undoubtedly possibilities before this type of currant, and for this reason, if for no other, the introduction of the Crandall has been fortunate. The plant grows readily from seeds, and we now have several hundred seedlings.

The Crandall so far has been free from attacks of the currant worm, although our plants grow in a general currant and gooseberry plantation in which the worms are common. It has been seriously attacked by the spot disease of the leaves, however (*Septoria ribis*), especially late in the season when the crop is nearly off and from that time until the leaves drop. The leaves develop many brownish spots of a circular outline and which are an eighth of an inch or more across. As the tissue in these spots dies, the portion becomes more or less translucent.



Flowers of Crandall Currant.
(Half size.)

Finally the whole leaf yellows and drops. If the attack should be serious upon young leaves, they never attain their full growth. This disease has been successfully treated by Professor Pammel with sprays of Bordeaux mixture and ammoniacal carbonate of copper.*

Ribes aureum, to which species the Crandall belongs, is native to a large area from Missouri and Arkansas westward. It has long been cultivated in yards for the long sweet yellow flowers, which are shown half size in the engraving. It is also sold by some nurserymen as *Ribes fragrans*.

DWARF JUNE BERRY.—AMELANCHIER CANADENSIS VAR. OBLONGIFOLIA.†

Two or three forms of this interesting little fruit have been introduced to cultivation within the past few years, of which the best known is the variety called Success. This variety was brought to notice by H. E. VanDeman, United States Pomologist, who found the plants growing in a garden in Kansas in 1873.‡ The variety was named and put upon the market about 1878 by Mr. VanDeman. We procured 200 plants in the spring of 1888, and these have now given us three good crops. The plants have never been headed in but they do not stand more than three or four feet high at the present time, and they are upon strong soil. They were set three feet apart and the sprouts are now beginning to fill the row.

The fruit ripens here with the early currants and lasts nearly as long as the currants. Last year, the last fruits were picked July 18. The accompanying picture shows a good cluster, full size. The berries closely resemble huckleberries, as well in flavor as in appearance. They are more juicy and palatable than huckleberries, however. The plants are exceedingly productive and hardy. Professor Alwood, of the Virginia Experiment Station writes in the *Southern Planter*: § "The fruit which is now, June

* See Bull. 13, Iowa Exp. Sta.

† *Amelanchier Canadensis* var. *oblongifolia*, Torrey and Gray, Fl. N. Am. i. 473 (1838). *A. Canadensis* var. *obovatis*, Sargent, Silva N. Am. iv. 128 (1892)? This dwarf Juneberry is undoubtedly a distinct species from *A. Canadensis*.

‡ See Annals Hort. for 1891, 51, for a fuller history.

§ *Southern Planter*, liii. 400 (July, 1892).

16th, just ripening, is nearly as large as ordinary smooth peas, and has a pleasant, sweet taste, accompanied by a not easily described but pleasant aroma. In quality it is, to my taste, superior to the huckleberry, and ranks well with the strawberry. I venture to predict that this fruit will become very popular, and fill a real need for a first-class small fruit, ripening just at the close of the strawberry season." Professor Alwood reaffirms this



Success Juneberry. (Natural size.)

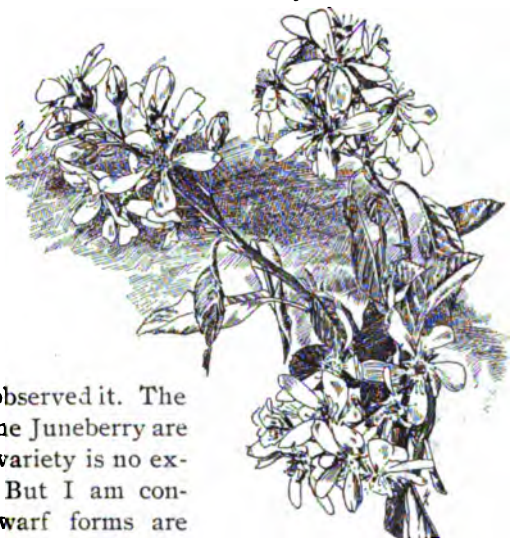
opinion in a recent bulletin.* I subscribe to the above encomium. The fruit is excellent whether eaten from the hand, dried in sugar, or otherwise prepared.

There is one serious difficulty in the cultivation of this fruit, however, which we have not been able to overcome—the incursions of the robins. There is no fruit on our plantation which is so irresistible to the birds as this, and nothing short of actual shooting will keep them away. The only way in which we can save a single fruit is to cover the branch with mosquito netting and

* Bull. 22, Va. Exp. Sta 109.

tie or sew it on securely, and even then the birds often steal the fruit. It has been suggested that if we had an acre of Juneberries, there would be enough fruit for the birds and ourselves, too ; but the robins of the whole country-side seem to know our Juneberry patch, and if we had more berries the only result would be, I fear, that we should have more robins.* But the birds bear me out in the statement that the Juneberries are good !

This dwarf Juneberry or service-berry grows wild over a large part of the northern states, always remaining a low bush so far as I have observed it. The natural variations of the Juneberry are perplexing, and this variety is no exception to the rule. But I am convinced that these dwarf forms are specifically distinct from the common tree-like Juneberry or Shad-bush (*Amelanchier Canadensis*). We are not yet ready to report upon other cultivated varieties of Juneberry, but the Success is an acquisition if the birds can be induced to avoid it.



Flowers of Success Juneberry.
(Half size)

L. H. BAILEY.

* Professor Budd writes as follows upon this point in a recent number of *Rural Life* (Feb. 16, 1893, p. 12): "The great drawback to the culture in a small way of the Dwarf Juneberry is the special fondness of the birds for the fruit. In plantations of an acre or more the fruit taken by the birds is hardly missed, but it is difficult to secure a perfect specimen from a half dozen or a dozen plants, unless they are covered. In the near future the tanned bird-netting for covering such fruits as the Juneberry and cherry, which we now are compelled to import, will be manufactured in our country. The inquiries we now have lead us to hope that the manufacture will be commenced the coming year." This material can be had of George Robinson, Rye, Sussex, England, and can be delivered in America for about three cents per yard.

BULLETINS OF
Cornell University Agricultural Experiment Station.
1888 TO 1892 INCLUSIVE.

No. 1, Experimental Dairy House ; No. 2, Feeding Lambs for Fat and Lean ; No. 3, Insectary of Cornell University, Wireworms, Plum Curculio ; No. 4, Growing Corn for Fodder and Ensilage ; No. 5, Lean meat in Mature Animals, Heating Milk before Setting ; No. 6, Fodders and Feeding Stuffs ; No. 7, Influences Affecting Sprouting of Seeds ; No. 8, Different Rations for Fattening Lambs ; No. 9, Windbreaks in their Relation to Fruit Growing ; No. 10, Tomatoes ; No. 11, Saw Fly Borer in Wheat ; No. 12, Apparatus for Drying in Hydrogen and Extracting Fat ; No. 13, Leaching of Farm Yard Manure, Grain for Cows at Pasture ; No. 14, Strawberry Leaf Blight ; No. 15, Sundry Investigations of 1889 ; No. 16, Growing Corn for Fodder and Ensilage ; No. 17, Cochran's Method for Testing Milk ; No. 18, Experiences in Spraying ; No. 19, Condition of Fruit Growing in Western New York ; No. 20, Cream Raising by Dilution ; No. 21, Tomatoes ; No. 22, Grain for Cows at Pasture ; No. 23, Insects Injurious to Fruit ; No. 24, Clover Rust ; No. 25, Sundry Investigations of 1890 ; No. 26, Egg Plants ; No. 27, Farm Manures ; No. 28, Forcing Tomatoes ; No. 29, Cream Raising by Dilution ; No. 30, Influence of Electric Light on Greenhouse Plants ; No. 31, Forcing English Cucumbers ; No. 32, Tomatoes ; No. 33, Wireworms ; No. 34, Dewberries ; No. 35, Combination of Fungicides and Insecticides ; No. 36, Grain for Cows at Pasture ; No. 37, Sundry Investigations of 1891 ; No. 38, Native Plums and Cherries ; No. 39, Creaming and Aerating Milk ; No. 40, Removing Tassels from Corn ; No. 41, Steam and Hot Water for Heating Green Houses ; No. 42, Electro-Horticulture ; No. 43, Trouble of Winter Tomatoes ; No. 44, Pear Tree Psylla ; No. 45, Tomatoes ; No. 46, Mulberries ; No. 47, Feeding Lambs and Pigs ; No. 48, Spraying Apple Orchards ; No. 49, Sundry Investigations of 1892.

Of these numbers, 2, 4, 5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19, 23, 25, 26, 27, 29, 32, 33, 34, 35, 36, 37, are out of print; the remainder will be sent to any desiring them.

Bulletin 52.

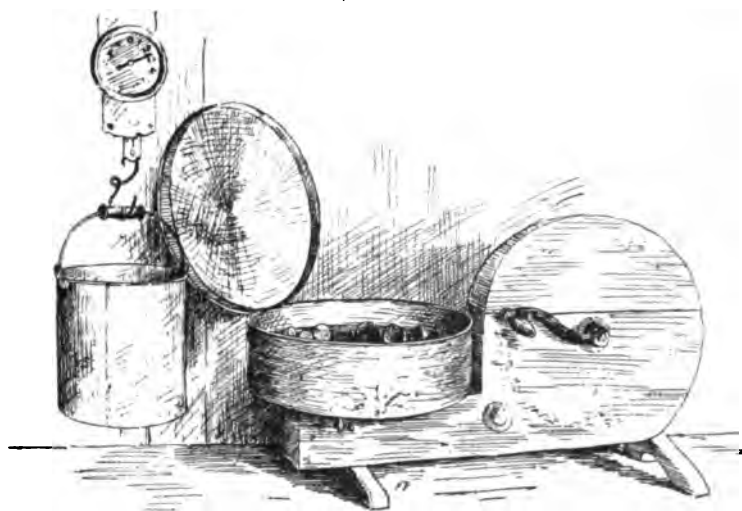
May, 1893.

Cornell University Agricultural Experiment Station.

AGRICULTURAL DIVISION.

COST OF MILK PRODUCTION.

VARIATION IN INDIVIDUAL COWS.



By HENRY H. WING.

PUBLISHED BY THE UNIVERSITY.

ITHACA, N. Y.

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Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1893.

50. The Bud Moth.
51. Four New Types of Fruits.
52. Cost of Milk Production.—Variation in Individual Cows.

COST OF MILK PRODUCTION—VARIATION IN INDIVIDUAL COWS.

So much has been said of late in Farmers' Institutes, in the Agricultural Press and in the Bulletins and Reports of Agricultural Experiment Stations, in regard to the yield of milk and butter that may be obtained from cows, and in regard to the improvement of herds, that it has seemed well to undertake a record which should if possible show not only what a fairly good herd can be made to produce, but what such production costs in dollars and cents and in the amount of dry matter consumed. In regard to these last two items there is comparatively little data at present, accessible. Most of the large records that have been reported by our enterprising breeders of thoroughbred stock have not been accompanied with any statement of the amount or cost of the material consumed to produce these records. Some of our Experiment Stations have made reports of experiments covering these points, but in general they have been made with a few animals and covering a comparatively short period of time. In view of the general interest in these matters it has seemed to us worth while to keep a record as exact as might be not only of the milk and butter production but of the amount and cost of the food consumed as well. Consequently beginning January 15, 1892, and ending January 14, 1893, a record of the amount fed and the amount produced by each individual cow in the University herd has been kept. The food was weighed separately for each cow at each feeding and charged to the animal consuming it. The milk was weighed at each milking and credited to the animal producing it. Once each week a sample of an equal amount of night's and morning's milk was taken from each cow. The fat in these samples of mixed milk was determined by Dr. Babcock's centrifugal method, and this percentage multiplied by the number of pounds of milk given during the week was taken to represent the number of pounds of fat produced during that week. The Uni-

versity herd during the time of the experiment contained twenty cows. It has been developed from the ordinary stock of the neighborhood by the use of thoroughbred bulls and a rigid selection of the best heifer calves. This course of breeding was established by Professor Roberts in 1875, and has been continued ever since. The year previous the yield of the cows upon the farm had been a little more than 3,000 pounds per cow. The descendants of these same cows, as will be seen in detail a little later on, produced in 1892 more than 7,000 pounds per cow. Special animals were not selected for this experiment; every cow in the herd without exception was taken. It was thought that by doing this, average results of more value would be obtained than though most of the better individuals were selected for the special purpose and a few of the poorer ones discarded.

In the table following (Table I) is given the pounds of milk and fat produced by each cow during the entire year and also the age of the cow at the beginning of the experiment. A large number of the cows were young, *four were three-year-olds and four heifers with their first calves; three of the latter were under two years old at the beginning of the experiment.* Four of the cows were not bred upon the farm and their ages were not definitely known, except that they were more than seven years old at the time of the beginning of the experiment. The column for age is left blank in the case of these cows. Two of these cows, Shadow and Sue, were of the common or mixed stock of the neighborhood and evidently carried considerable Short Horn blood. They were not bred and were sold for beef in the Fall of 1892, so that their year extends from October 15, 1891, to October 14, 1892, in the case of Shadow, and from November 20, 1891, to November 19, 1892, in the case of Sue instead of from January 15, 1892, to January 14, 1893, as in the case of all the others. No accidents or sickness interrupted the experiment with one exception; the cow May was farrow at the beginning of the experiment, having then been in milk more than a year. She dropped a heifer calf on November 20th and did very nicely, giving a large flow of milk till December 26th, when she was attacked with a violent chill followed by a fever and almost complete loss of appetite. She dried up rapidly and was removed from the experiment on Jan-

uary 5th. Inasmuch as the experiment was so nearly closed it was not thought worth while to take account of this and her record simply lacks the nine days of a complete year.

TABLE I—TOTAL YIELD IN ONE YEAR.

Cow.	Age. Yr. Mo.	Milk. Lbs.	Butter fat. Lbs.
Beauty	—	8,028.50	391.62
Belva	5 — 4	9,739.75	309.19
Bertha	3 — 5	4,743.25	233.63
Carrie	1 — 9	6,008.50	219.34
Cora	—	6,214.50	326.68
Daisy	1 — 10	2,829.75	159.02
Freddie	6 — 4	11,165.00	417.97
Gazelle	4 —	5,670.50	285.10
Gem Valentine	3 —	3,387.75	197.33
Glista	4 — 8	6,323.50	224.71
Glista 2d	1 — 9	5,136.00	160.79
Jennie	3 — 5	5,785.75	294.30
May	10 — 4	5,458.50	195.31
Mollie	2 — 4	7,757.25	260.34
Pearl	3 — 4	9,003.25	299.07
Pet	6 — 4	9,776.50	330.59
Puss	7 — 3	10,417.00	302.93
Ruby	3 — 4	7,955.00	282.35
Shadow	—	8,655.50	382.77
Sue	—	10,754.00	439.37
Total		144,809.75	5,712.41
Average		7,240.50	285.62

It will be seen that the average yield of milk was 7,240 pounds per cow and the average yield of fat 285 pounds, but it will be also seen that these averages are the averages of wide variations.

The least yield of milk was by Daisy, not quite 3,000 pounds; the largest by Freddie, something over 11,000 pounds, nearly four times as much. Similar variations are seen in the yield of fat and as is to be expected the largest yields of fat were not in all cases from the cows giving the most milk though attention is called to the fact that the cow giving the largest yield of fat, 439 lbs., was second in milk production, 10,754 lbs., and the cow giving the largest yield of milk, 11,165 lbs., was second in fat production, 418 lbs. In tables II, III, and IV are given in detail for

TABLE II.—YIELD OF MILK FOR EACH COW EACH MONTH.

Cow.	Jan. '92 1-31 Lbs.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan. '93. 1-14 Lbs.
Beauty	469.	1033.	1021.50	887.	879.75	801.	627.	403.75	115.75	—	473.25	931.50	386.
Belva	695.	992.75	938.	874.75	969.	826.25	424.75	—	—	1170.	1184.75	1233.50	431.
Bertha	271.	435.	414.50	375.	393.	374.	77.	—	—	618.75	745.75	731.50	307.75
Carrie	339.50	569.25	601.50	573.50	577.	539.	469.	444.	462.50	424.75	372.	429.75	206.75
Cora	255.75	859.25	862.	807.25	838.25	781.50	697.	449.25	301.25	65.	—	—	298.
Daisy	134.75	228.25	239.75	232.25	240.75	240.75	48.50	—	81.75	476.75	359.	387.25	160.
Freddie	737.	1200.25	1231.50	1097.50	956.50	921.25	370.	—	497.50	1351.25	1126.75	1158.	517.50
Gazelle	—	393.50	771.75	712.75	708.	641.25	558.	477.50	353.25	114.50	—	602.	341.
Gem Valentine	39.25	—	108.75	542.25	541.50	510.	448.50	408.50	355.75	279.	154.25	—	—
Glista	405.75	677.50	700.50	615.75	639.	601.50	482.	370.50	—	327.25	553.75	642.25	307.75
Glista 2d	324.75	553.25	643.50	613.75	578.75	508.50	440.	411.	367.	56.75	38.	401.50	199.25
Jennie	—	—	505.	756.75	703.75	649.	576.	538.50	521.75	478.	410.	445.	202.
May	386.50	652.	651.50	596.75	608.75	581.75	419.75	129.50	—	—	210.50	1153.75	67.75
Mollie	478.50	754.50	808.	729.	802.	694.50	94.75	—	554.50	867.75	704.75	860.75	408.25
Pearl	611.25	1024.25	884.75	905.25	865.	589.75	45.	—	411.50	1173.25	924.	1080.25	489.
Pet	—	—	1019.75	1329.75	1411.	1291.75	1146.75	1060.25	1061.25	873.50	445.50	137.	—
Puss	814.25	1291.50	1426.75	1210.50	1167.	1036.50	950.50	870.25	789.75	630.75	229.25	—	—
Ruby	476.25	738.	822.25	812.25	847.75	814.75	699.50	576.25	273.	—	258.25	1104.50	532.25
Shadow	1014.25	865.	814.50	730.75	716.50	637.	537.	463.75	367.	*593.50	*877.	*1039.25	—
Sue	1265.75	1074.75	1070.50	974.00	974.25	888.50	766.50	664.25	569.25	—	654.50	*1345.	—

*1891.
1891 and 1892.

TABLE III.—PERCENTAGE OF FAT IN THE MILK OF EACH COW EACH MONTH.

Cow.	Jan. '02. Per ct.	Feb. Per ct.	Mch. Per ct.	April. Per ct.	May Per ct.	June Per ct.	July. Per ct.	Aug. Per ct.	Sept. Per ct.	Oct. Per ct.	Nov. Per ct.	Dec. Per ct.	Jan. '03. Per ct.
Beauty.....	5.63	5.05	4.50	4.53	4.93	4.70	5.01	5.34	5.19	—	5.50	4.59	4.67
Belva	2.92	3.02	3.17	3.11	3.11	2.90	3.15	—	—	3.88	2.94	3.30	3.12
Bertha	5.16	5.05	5.30	5.22	5.23	4.95	4.95	—	—	4.64	4.59	5.21	3.98
Carrie.....	3.50	3.32	3.33	3.27	3.82	3.70	3.63	—	3.86	3.98	4.09	3.80	3.79
Cora	4.66	5.37	5.36	5.15	5.39	4.96	5.04	3.74	3.86	6.46	—	—	4.67
Daisy	5.80	5.84	6.06	6.15	6.48	5.76	5.55	5.67	6.02	—	—	—	5.83
Freddie.....	3.55	3.71	3.85	3.89	4.11	3.65	3.95	—	5.20	5.24	5.07	5.20	5.62
Gazelle.....	—	4.86	5.22	4.97	5.39	4.68	4.62	—	4.14	3.68	3.27	3.78	3.62
Gem Valentine.....	7.80	—	6.13	5.57	5.63	5.60	5.54	5.14	5.00	5.85	—	5.13	4.92
Glista	3.47	3.24	3.31	3.22	3.66	3.56	3.63	5.93	6.05	6.49	6.25	—	3.75
Glista 2d	3.09	2.92	2.87	2.90	3.14	3.22	3.33	3.25	3.48	3.81	2.97	3.47	2.88
Jennie.....	—	—	5.30	5.27	4.97	4.58	4.62	5.11	5.23	5.16	5.34	5.41	5.41
May	3.49	3.33	3.17	3.07	3.30	2.99	3.40	3.37	—	—	6.08	4.32	3.50
Mollie	3.27	3.24	3.38	3.19	3.57	3.69	3.95	—	3.81	3.01	3.06	3.19	3.45
Pearl.....	3.08	3.19	3.77	3.39	3.51	3.61	4.80	—	3.60	3.18	2.88	3.26	3.21
Pet.....	—	—	3.40	3.23	3.25	3.01	3.27	—	3.50	3.63	4.04	5.57	—
Puss	2.84	2.67	3.12	3.16	2.61	2.62	2.75	2.80	3.08	3.34	4.00	—	—
Ruby.....	3.50	3.83	3.55	3.49	3.33	3.22	3.34	3.92	4.08	—	—	3.77	3.49
Shadow.....	4.28	4.58	4.76	4.61	4.16	3.76	4.24	4.44	4.27	4.57	4.66	4.48	—
Sue.....	3.94	3.94	4.33	4.28	4.45	3.72	3.71	3.70	4.04	4.10	4.30	4.30	—

TABLE IV.—YIELD OF FAT FOR EACH COW EACH MONTH.

Cow.	Jan. 1891, Lbs.	Feb. Lbs.	March. Lbs.	April. Lbs.	May. Lbs.	June. Lbs.	July. Lbs.	Aug. Lbs.	Sept. Lbs.	Oct. Lbs.	Nov. Lbs.	Dec. Lbs.	Jan. 1892, Lbs.
Beauty	26.41	52.18	46.01	40.21	43.36	37.66	31.44	21.56	6.01	—	26.04	42.71	18.03
Belva	20.32	30.	29.76	27.17	30.11	23.98	13.36	—	—	45.44	34.88	40.71	13.46
Bertha	13.99	21.96	21.98	19.56	20.54	18.51	3.81	—	—	28.74	34.21	38.08	12.25
Carrie	11.89	18.92	20.06	18.74	22.05	19.93	17.03	16.61	17.87	16.92	15.20	16.29	7.83
Cora	11.91	46.15	46.24	41.56	45.17	38.76	35.13	25.49	18.15	4.20	—	—	13.92
Daisy	7.82	13.34	14.53	14.29	15.59	13.87	2.69	—	4.25	24.99	18.19	20.13	9.33
Freddie	26.18	44.49	47.44	42.74	39.34	33.64	14.60	—	20.59	49.66	36.82	43.74	18.73
Gazelle	—	19.11	40.24	35.39	38.00	30.01	25.78	24.52	17.67	6.70	—	30.91	16.77
Gem Valentine	3.06	—	6.67	30.20	30.48	28.55	24.86	24.24	21.53	18.10	9.64	—	—
Glista	14.09	21.96	23.22	19.81	23.37	21.41	17.50	15.19	—	13.11	20.52	23.00	11.53
Glista 2d	10.02	16.17	18.45	17.82	18.17	16.38	14.67	13.36	12.77	2.18	1.13	13.94	5.73
Jennie	—	—	26.75	39.91	34.95	29.71	26.62	27.53	27.30	24.65	21.89	24.07	10.92
May	13.50	21.69	20.63	18.33	20.07	17.40	14.28	4.36	—	—	12.80	49.88	2.37
Mollie	15.64	24.45	27.31	23.27	28.60	27.05	3.74	—	21.15	26.08	21.54	27.42	14.09
Pearl	18.85	32.70	33.37	30.67	30.38	21.27	2.16	—	14.80	37.34	26.62	35.19	15.72
Pet	—	—	34.71	43.01	45.91	38.86	37.51	36.11	37.19	31.67	17.99	7.63	—
Puss	23.09	34.50	44.54	38.23	30.44	27.12	26.11	24.37	24.31	21.06	9.16	—	—
Ruby	16.66	28.28	30.04	28.32	28.23	26.26	23.38	22.59	11.13	—	9.73	39.17	18.56
Shadow	43.36	39.60	38.77	33.69	29.83	23.92	22.76	20.58	15.67	*27.12	*40.91	*46.56	—
Sue	49.82	42.34	46.38	41.66	43.31	33.07	28.45	24.58	22.97	20.76	†28.13	*57.90	—

* 1891.

† 1891-1892.

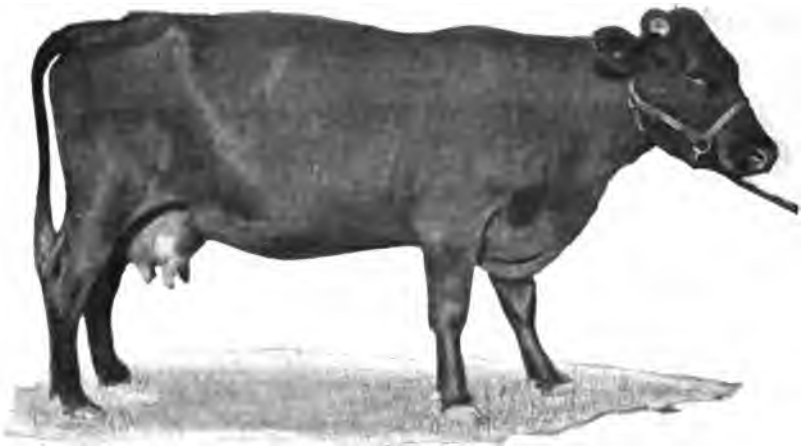


FIG. 1. *Sue, First in Fat, Second in Milk.*



FIG. 2. *Puss, Third in Milk.*



FIG. 3. *Freddie, First in Milk, Second in Fat.*



FIG. 4. *Beauty, Third in Fat.*

each month the total yield of milk, the average per cent. of fat in the milk, and the total yield of fat. In these Tables and in all the following discussions we have based our figures upon the actual fat produced by the cow as determined by the Babcock Test and not upon the amount of butter that such fat might be expected to make. We have done this because we believe it to more accurately measure the producing powers of the different cows. But since butter has to many a more intelligible significance than fat we have made the following calculations.

The average yield of fat per cow was 285.62 lbs. If all this fat had been made into butter that contained 80 per cent. of fat* we should have had a butter yield of 357 lbs. per cow. The best cow gave 439.37 lbs. of fat. On the same basis this would be equivalent to 549 pounds of butter.

But not all the fat can be made into butter, some is unavoidably lost in the skim-milk and in the butter-milk. Assuming that four-fifths of all the milk would be skim-milk and that it would contain .25 of one per cent. of fat and that three-fourths of the cream would be butter-milk and it should contain .5 of one per cent. of fat, we should lose in this way 398.23 lbs. of fat or 19.91 lbs. per cow, equivalent to 24.9 pounds of butter. This subtracted from 357 would leave the average yield of butter per cow 332 pounds after making due allowance for the losses in skim-milk and butter-milk.

The cows in general are fresh in the months of September and October of each year. In table No. V are shown the dates at which calves were dropped both before and during the experiment and also the number of days that each cow was actually milked from Jan. 15, 1892, to January 14, 1893. It will be seen that one cow, May, was farrow at the time of the beginning of the experiment, that two others, Carrie and Jennie, went farrow during the experiment, and that Shadow and Sue were not bred. The general plan of treatment of the University herd is that the cows shall be milked ten months in the year, going dry about eight weeks before calving. On referring to the last column of table V it will be seen that this is very nearly practically carried out and that the average number of days of milking was 304; almost exactly ten months.

*This is the standard adopted by the judges of the Dairy Test at the World's Columbian Exposition.

TABLE V.—DATES OF CALVING.

Cow.	Dropped calf before or in early part of experiment.	Dropped calf during or at close of experiment.	Days in milk between Jan. 15, 1892 and Jan. 14, 1893.
Beauty.....	Jan. 15, 1892	Nov. 9, 1892	314
Belva	Oct. 2, 1891	Sept. 26, 1892	295
Bertha	Sept. 16, 1891	Oct. 7, 1892	273
Carrie	Oct. 28, 1891	*(Aug. 8, 1893)	366
Cora.....	Jan. 16, 1892	Dec. 31, 1892	278
Daisy.....	Sept. 20, 1891	Sept. 22, 1892	287
Freddie.....	Oct. 6, 1891	Sept. 15, 1892	309
Gazelle.....	Feb. 8, 1892	Dec. 1, 1892	288
Gem Valentine..	Mar. 21, 1892	*(Jan. 26, 1893)	252
Glista.....	Sept. 21, 1891	Oct. 9, 1892	324
Glista 2d.....	Sept. 29, 1891	Nov. 21, 1892	316
Jennie	Mar. 5, 1892	*(Sept. 7, 1893)	311
May	(Dec. 27, 1890)	Nov. 20, 1892	257
Mollie.....	Sept. 25, 1891	Sept. 10, 1892	298
Pearl	Sept. 1, 1891	Sept. 16, 1892	292
Pet.....	Mar. 2, 1892	*(April 16, 1893)	285
Puss	Dec. 10, 1891	*(Feb. 2, 1893)	317
Ruby	Sept. 11, 1891	Nov. 14, 1892	302
Shadow.....	Oct. 12, 1891	Not bred	352
Sue.....	Nov. 16, 1891	Not bred	366

Average number of days in milk.....304

*Due to calve.

The cows were weighed on the 15th of each month except in a few cases where dry cows were at pasture and away from the barn. They were weighed in every case in the morning after milking and feeding and before watering. The weights of each cow each month are shown in table VI and also the average for the year.

It will be seen that the herd as a whole maintained about an even degree of flesh, only a few of the younger cows making a material increase in weight during the year. It will also be seen that the size of the cows varied considerably and that very few were under 1000 pounds in average weight, so that the herd as a whole was made up of large cows.

It was the aim to feed a ration that would be eaten up fairly clean by all the cows. The foods used during the winter were hay, ensilage, roots, wheat bran, cotton-seed meal and corn meal. Only very slight variations were made from this list of foods. In the summer the cows had pasture of good quality and a grain

TABLE VI.—WEIGHT OF COWS EACH MONTH.

Cows.	Jan. 1892.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec. 1892.	Jan. 1893.	Aver- age.
Beauty	—	880	875	885	830	805	865	865	890	—	880	820	845	858
Belva.....	1254	1244	1262	1325	1265	1350	1405	1400	1425	1290	1442	1300	1275	1326
Bertha.....	900	935	955	975	945	1050	970	970	970	925	895	895	915	946
Carrie.....	847	896	962	1000	935	970	945	945	940	1010	1050	1070	1070	972
Cora.....	1235	1088	1115	1135	1025	1070	1095	1090	1095	1185	1225	1210	1030	1123
Daisy.....	610	748	800	820	795	815	855	855	897	815	845	840	895	815
Freddie.....	1477	1485	1520	1492	1455	1500	1565	1545	1525	1375	1430	1430	1365	1474
Gazelle.....	1135	1094	1105	1110	1015	1055	1075	1040	1050	1080	1130	1005	1035	1071
Gem Valentine.	807	849	900	835	765	800	815	800	805	840	845	865	850	829
Glista.....	1208	1255	1273	1305	1250	1300	1320	1345	1325	1225	1255	1250	1195	1270
Glista 2d.....	883	920	975	1015	980	970	965	1005	990	1095	1115	1025	1070	1001
Jennie.....	1076	1100	1020	1060	1000	1030	1030	985	970	1010	1005	1045	1065	1030
May.....	1252	1290	1290	1310	1230	1330	1365	1325	1330	—	1447	1195	1035	1283
Mollie.....	963	992	1026	1025	995	1060	1020	1040	940	960	1015	1025	1035	1007
Pearl.....	1095	1093	1128	1145	1080	1180	1260	1250	1295	1105	1155	1140	1155	1160
Pet.....	1430	1472	1270	1265	1200	1255	1275	1230	1185	1255	1448	1325	1360	1305
Puss.....	1482	1517	1510	1565	1425	1500	1525	1465	1475	1535	1600	1630	1525	1520
Ruby.....	1133	1148	1187	1215	1160	1245	1265	1255	1275	—	1180	1060	1070	1183
Shadow.....	1148	1192	1165	1245	1170	1245	1355	1245	1270	1350	—	—	—	1239
Sue.....	1094	1093	1105	1015	995	940	1030	1015	960	1065	1130	—	—	1040

ration, for the most of the time, of wheat bran and cotton-seed meal, supplemented with soiling crops when the pastures became dry.

The hay used was clover hay of a fair quality grown upon a wheat stubble and having a considerable proportion of volunteer wheat mixed with it, which was not readily eaten by the cows. The silage was made from Pride of the North corn grown in hills carrying a fair crop of ears. It was well preserved and of good quality. The roots used were almost wholly Mangel Wurtzels of medium size and good quality. The grain ration in January, February, March and April, 1892, was made up of a mixture of 300 pounds of bran, 200 pounds of cotton-seed meal and 60 pounds of corn meal. The corn silage crop of 1892 had considerably more grain than that of 1891, consequently, in November and December, 1892, and the first half of January, 1893, the corn meal was left out of the grain ration and three parts of bran and two parts of cotton-seed meal were fed. During the time the cows were at pasture the grain ration was made up of three parts bran and one part cotton-seed meal. The daily winter ration was as follows:

For the larger cows.

15 lbs. hay.
50-55 lbs. silage.
10 lbs. roots.
8 lbs. grain.

For the smaller cows.

10 lbs. hay.
40-45 lbs. silage.
10 lbs. roots.
8 lbs. grain.

The only exceptions made to this were that Freddie and Puss, during January, February and March, 1892, had ten pounds of grain instead of eight. The summer grain ration was four pounds per cow except during the month of June when one-half of the cows received no grain whatever. The cows while dry were fed no grain at all, the remainder of the ration being unchanged. In the latter part of the summer, particularly in the months of August and October, the pastures became very short and were supplemented in August with second growth clover, cut and carried to the cows, and in October with corn stalks. These were in every case weighed and charged to the cows consuming them. In making up the cost of the food consumed the following scale of prices was used, based as far as possible upon the market prices in Ithaca:

Hay	\$ 9.00 per ton.
Ensilage	1.75 per ton.
Roots	2.00 per ton.
Wheat bran	18.00 per ton.
Oats	.35 per bu.
Cotton-seed meal	25.00 per ton.
Corn meal	20.00 per ton.
Corn stalks	3.00 per ton.
Grass, cut and carried to cows	1.75 per ton.
Pasture, exclusive of grain and silage crops..	.30 per wk.

It was somewhat difficult to estimate the value of the corn-stalks and the second growth clover used for soiling, since the materials, particularly the cornstalks, varied widely in the amount of water contained in them. But as fair an estimate as could be made seemed to be the figures given. In order to estimate with some degree of accuracy the proper charge to be made for pasture, the following letter was sent to representative farmers in thirteen counties in those parts of the state where dairying is a leading industry:

"DEAR SIR:—

Will you please tell me what you consider a fair estimate per week of the cost of pasturing a cow in milk during the whole season; not what people in villages pay for a cow or so, but what it costs dairymen keeping cows in large herds. Please base your estimates upon your own county."

To this, thirteen replies were received from the counties of Broome, Cattaraugus, Chautauqua, Chemung, Cortland, Delaware, Dutchess, Lewis, Montgomery, Oneida, Orange, St. Lawrence and Tompkins. The average of the whole was \$.33 per week. Three of the replies were above 45 cents; eight between 25 and 35 cents, and two were below 25 cents. A discussion of the matter, by the various members of the Station Staff, had already decided upon 30 cents as a fair price, and that price has been used as the value of the pasture. The cows were charged with pasturage from May 9th to November 1st. During November they were turned in the pasture on pleasant days and ate more or less grass; but as they were on full winter rations, both of grain and coarse fodder during the month, it was not thought best to make any charge for the small amount of frosted grass they might have eaten.

In Table VII is given the cost of the food consumed by each animal; the total number of pounds of milk and fat produced and the cost of a hundred pounds of milk and one pound of fat for each individual and the average for the whole. The average

TABLE VII—COST OF FOOD, MILK AND FAT.

Cow.	Cost of food consumed during the year.	Pounds of milk produced.	Cost of 100 pounds of milk.	Pounds of fat produced.	Cost of one pound of fat.
Beauty	\$44.24	8,028.50	\$.55	391.62	\$.115
Belva	47.65	9,739.75	.49	309.19	.155
Bertha	42.00	4,743.25	.89	233 63	.18
Carrie	49.07	6,008 50	.82	219 34	.225
Cora	38.74	6,214 50	.62	326.68	.12
Daisy	41.24	2,829.75	1.48	159.02	.26
Freddie	52.06	11,165.00	.47	417.97	.125
Gazelle	39.96	5,670 50	.70	285.10	.14
Gem Valentine	36.24	3,387.75	1.07	197.33	.185
Glista	46.51	6,323.50	.74	224.71	.21
Glista 2d	43.80	5,136.00	.85	160.79	.27
Jennie	43.66	5,785.75	.75	294.30	.15
May	44.34	5,458.50	.81	195.31	.225
Mollie	45.98	7,757.25	.59	260.34	.175
Pearl	47.44	9,003.25	.53	299.07	.16
Pet	43 12	9,776.50	.44	330.59	.13
Puss	47.87	10,417.00	.46	312.93	.16
Ruby	48.63	7,955.00	.61	282 35	.17
Shadow	53.38	8,655.50	.62	382.77	.14
Sue	49.08	10,754.00	.46	439.37	.11
Total	\$905.01	144,809.75		5,712.41	
Average	45.25	7,240.50	\$.625	285.62	\$.158

cost of food consumed was \$45.25; the highest for any one cow was \$53.38 for the cow Shadow; the lowest \$36.24 for Gem Valentine. The average cost of 100 pounds of milk was almost exactly 62½ cents; the highest for any one cow being \$1.48 for Daisy; the lowest 44 cents for Pet. If we consider milk to be worth \$1.00 per hundred weight at the barn two of the cows produced milk at a loss, Daisy and Gem Valentine. The average cost of butter fat was 15.8 cents; the highest 27 cents for Glista 2d; the lowest 11 cents for Sue. If we should consider fat to be worth 30 cents per pound, which is a little more than an equivalent of 25 cents a pound for butter, we should have no cows that produced fat at a loss for food consumed.

Of course, in making comparisons of cows in this way it is necessary that the individual history of the cows be taken into account. For instance, in our herd two cows, Daisy and Glista 2d, were under comparatively unfavorable conditions; because of

an accident they had dropped their calves when about eighteen months old and after having run in a back pasture where they were overlooked until they had been seriously annoyed by the horn fly. They were retained in the herd for another year, and one of them, Daisy, showed marked improvement. The other, Glista 2d, did not, and, therefore, has already been sent to the butcher, while Daisy is retained for still further development. This is mentioned simply to show the principles upon which we base our selections. In the same way the cow May was under unfavorable conditions as she had already been milked more than a year when the experiment started, and in this year had given more than 13,000 pounds of milk, and it was not to be expected that in the second year she would do as well. On the other hand the cow Pet was fresh in March and in full flow of milk during the time that the pasture was at its best. Her cost of milk and fat in comparison with others of her age and weight is therefore probably quite a little reduced. But after taking into account

TABLE VIII.—COST OF 100 POUNDS OF MILK FOR EACH MONTH.

Cow.	Jan., '92.	Feb.	Mar.	April	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan., '93.
Beauty ..	.57	.49	.53	.58	.49	.31	.41	.87	—	—	—	.52	.54
Belva. .	.49	.56	.64	.66	.48	.17	—	—	—	.25	.41	.49	.63
Bertha...	1.09	1.16	1.31	1.37	1.10	.38	—	—	—	—	.55	.66	.68
Carrie ...	.87	.89	.90	.90	.75	.46	.55	.82	.58	.72	1.23	1.16	1.04
Cora.....	—	.60	.63	.64	.52	.18	.30	.78	.88	—	—	—	.59
Daisy.....	2.20	2.21	2.27	2.22	1.80	.59	—	—	—	.60	.82	1.24	1.31
Freddie.	.52	.54	.56	.54	.48	.27	—	—	—	.23	.43	.53	.52
Gazelle.	—	—	.70	.72	.62	.22	.38	.74	.75	—	—	.71	.61
Gem	—	—	—	—	—	—	—	—	—	—	—	—	—
Valent'e	—	—	—	.95	.80	.49	.57	.86	.75	1.10	—	—	—
Glista ...	.73	.74	.78	.84	.68	.24	.44	.99	—	—	.83	.86	.83
Glista 2d	.91	.91	.85	.84	.75	.28	.48	.89	.73	—	—	1.24	1.08
Jennie...	—	—	—	.68	.62	.38	.44	.65	.51	.64	1.03	1.09	1.03
May	.88	.90	.96	.98	.77	.43	.61	—	—	—	—	.44	.58
Mollie...	.62	.67	.67	.71	.54	.36	—	—	—	.35	.65	.64	.62
Pearl.....	.56	.58	.69	.65	.54	.24	—	—	—	.26	.49	.51	.52
Pet	—	—	—	.44	.33	.11	.18	.34	.25	.35	1.09	—	—
Puss	.47	.50	.48	.51	.40	.24	.27	.42	.34	.49	—	—	—
Ruby ...	.71	.79	.75	.72	.55	.30	.37	.63	—	—	—	.50	.48
Shadow.	.61	.68	.77	.80	.65	.39	.48	.76	.66	.41	.56	.60	—
Sue	.46	.51	.55	.59	.48	.16	.28	.55	.47	.61	.81	.43	—
Average	.64	.68	.71	.71	.58	.28	.38	.65	.51	.41	.65	.63	.67

TABLE IX.—COST OF ONE POUND OF FAT FOR EACH MONTH.

Cow.	Jan. '92.	Feb.	Mar.	April.	May.	Jun.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan. '93.
Beauty ..	.10	.095	.12	.13	.10	.065	.08	.165				.115	.115
Belva ...	.165	.185	.205	.215	.155	.06				.065	.14	.15	.20
Bertha...	.21	.23	.25	.265	.21	.075					.125	.125	.17
Carrie	.25	.265	.27	.275	.195	.145	.15	.22	.15	.18	.30	.305	.275
Cora		.11	.12	.125	.095	.035	.06	.14	.145				.125
Daisy. .	.38	.38	.375	.36	.28	.10				.115	.16	.24	.225
Freddie..	.145	.145	.145	.14	.12	.075				.06	.13	.14	.145
Gazelle..			.135	.145	.115	.05	.08	.14	.15			.14	.125
Gem													
Valett'e				.17	.14	.085	.105	.145	.125	.17			
Glista ...	.21	.23	.235	.26	.185	.065	.12	.24			.225	.24	.22
Glista 2d	.295	.31	.295	.29	.24	.085	.145	.275	.21			.36	.375
Jennie ..				.13	.125	.085	.095	.125	.095	.125	.195	.20	.19
May	.25	.27	.30	.32	.23	.14	.18					.105	.165
Mollie...	.19	.205	.20	.22	.15	.09				.12	.21	.20	.18
Pearl	.18	.18	.185	.19	.155	.065				.08	.17	.16	.16
Pet				.135	.10	.035	.055	.10	.07	.095	.27		
Puss	.165	.19	.155	.16	.155	.09	.10	.15	.11	.145			
Ruby	.20	.205	.205	.205	.165	.095	.11	.16				.14	.135
Shadow..	.145	.15	.16	.175	.16	.105	.11	.17	.155	.09	.12	.135	
Sue.....	.115	.13	.125	.14	.105	.045	.075	.15	.115	.15	.285	.10	
Average	.17	.18	.18	.18	.145	.075	.095	.155	.125	.105	.175	.155	.17

these individual variations the larger number of the animals may be fairly judged by their records as made. For instance, Bertha produced milk at \$.85 a hundred weight and fat at \$.18 per pound; her twin sister, Jennie, under the same conditions produced milk at \$.75 a hundred weight and fat at \$.15 per pound. Both of them were surpassed by Beauty and Cora, cows of like age and breeding, and so the comparison of others might be made. A single one is perhaps striking enough to merit attention. Glista and Belva are cows in outward appearance very similar and of nearly the same age and weight; Glista required seventy-four cents worth of food to make 100 pounds of milk, Belva forty-nine; nearly 50 per cent. less. Belva produced a pound of fat for fifteen and one-half cents, Glista for twenty-one cents; considerably more than one-third more. It is also of interest to note the varying cost of milk and fat in the different months of the year. This is shown in detail in Tables VIII and IX.

In Table VII the cost of milk is obtained by dividing the total cost of food for the year by the total number of pounds produced during the year. In Tables VIII and IX the cost per month is obtained by dividing the value of the food consumed in any given month by the amount of milk and fat produced in that month and the figures are therefore relatively lower because the amount consumed in the months when the cows were dry or partially dry is not taken into account, and figures are given only in the months where the cows were milked during the whole month. These tables show what might have been expected, that milk produced upon pasture is produced at a lower cost for food or that it costs more to produce milk on dry food in the winter than in the summer on pasture, and in this case the larger number of cows were fresh in the winter. But some other generalizations of interest may be drawn from these tables. It will be seen that the highest cost both for milk and fat was in the months of March and April, the lowest in June. It will be seen too that in the month of August the cost was higher than in either July or September. November also was a month in which the cost was relatively high. We have found that in the three months of April, August and November we have the greatest difficulty in getting a satisfactory return for the amount of food used. The cost of individual cows is also worthy of notice. It will be seen that one cow, Pet, produced milk for eleven cents per hundred weight in June, and that two cows, Cora and Pet, produced fat for three and a half cents per pound in the same month, and it will be seen a little further on that in this month these cows had nothing but pasture.

As a sort of side issue a study was made of the effect of a grain ration upon the cost of production of milk and fat. The study was made during the month of June in this way. The cows were first turned to pasture on May 9th; the winter grain ration of eight pounds per day was reduced to the summer ration of four pounds per day on May 26th; on June 3d the cows were divided into two lots, evenly mated as nearly as possible in regard to the yield of milk, age, size, time of calving, etc. One lot received no grain during the remainder of the month of June; the other lot continued to receive the customary allowance of four pounds.

TABLE X.—EFFECT OF GRAIN WITH PASTURE ON COST OF MILK.

Fed grain in June.				Fed no grain in June.			
Cow.	Cost of 100 pounds milk.		Reduction of cost in June. Per ct.	Cow.	Cost of 100 pounds milk.		Reduction of cost in June. Per cent.
	May.	June.			May.	June.	
Beauty.....	\$.49	\$.31	58	Belva.....	\$.48	\$.17	182
Carrie.....	.75	.46	63	Bertha.....	1.10	.38	189
Freddie.....	.48	.27	78	Cora.....	.52	.18	189
Gem Valentine	.80	.49	63	Daisy.....	1.80	.59	205
Jennie.....	.62	.38	63	Gazelle.....	.62	.22	182
May.....	.77	.43	79	Glista.....	.68	.24	183
Mollie.....	.54	.36	50	Glista 2d.....	.75	.28	168
Puss.....	.40	.24	67	Pearl.....	.54	.24	125
Ruby.....	.55	.30	83	Pet.....	.33	.11	200
Shadow.....	.65	.39	67	Sue.....	.48	.16	200
Average.....				67			
				182			

TABLE XI.—EFFECT OF GRAIN WITH PASTURE ON COST OF FAT.

Fed grain in June.				Fed no grain in June.			
Cow.	Cost of 100 lbs. of fat.		Reduction of cost in June. Per ct.	Cow.	Cost of 100 lbs. of fat.		Reduction of cost in June. Per cent.
	May.	June.			May.	June.	
Beauty.....	\$.10	\$.065	54	Belva.....	\$.155	\$.06	158
Carrie.....	.195	.125	56	Bertha.....	.21	.075	180
Freddie.....	.12	.075	60	Cora.....	.095	.035	171
Gem Valentine	.14	.085	65	Daisy.....	.28	.10	180
Jennie.....	.125	.085	47	Gazelle.....	.115	.05	130
May.....	.23	.14	64	Glista.....	.185	.065	185
Molly.....	.15	.09	67	Glista 2d. ...	.24	.085	182
Puss.....	.155	.09	72	Pearl.....	.155	.06	138
Ruby.....	.165	.095	74	Pet.....	.10	.035	186
Shadow.....	.16	.105	62	Sue.....	.105	.045	133
Average.....				62			
				164			

In tables X and XI is shown the relative cost of milk and fat in the two months of May and June. The cost of milk and fat was largely reduced in the month of June with all the cows, but the reduction was nearly three times as much with the lot that received no grain, and by a study of the column in tables X and XI showing the percentage of reduction in cost of milk and butter in June, it will be seen that the percentage of reduction was fairly uniform with all the cows in each lot. The percentage of reduction was quite as much with those producing a small amount of milk as with those producing a large amount of milk. In no case was the reduction in cost in a cow having grain as large as in a cow having no grain, and the average reduction for the lot having no grain was nearly three times as much as for those having grain. In general the milk was reduced in cost in June more than the fat, but this difference is not very marked. With the grain fed lot the cost of milk was sixty-seven per cent. and the cost of fat sixty-two per cent. less in June than in May; with the lot receiving no grain the cost of the milk was 182 per cent. and the cost of the fat 164 per cent. less in June than in May. It should be borne in mind that this reduction was effected in cows that were none of them fresh in milk and most of them well advanced in the period of lactation; it is interesting also to note that the four pounds of grain ration per day cost just as much as the pasture at thirty cents per week; in other words the addition of a grain ration doubled the cost of keeping the cows for that month.

In regard to the dry matter consumed, it was found impracticable to make any estimate of the dry matter consumed in the pasture, so that the figures of the dry matter consumed are based upon what the animals ate during the months of winter feeding, namely, November, December, January, February, March and April, and are given in Table XII. The percentages of dry matter in the various foods were taken from Jenkin's and Winton's Compilation of Analyses of American Feeding Stuffs (U.S. Dept. Agr., Experiment Station Bulletin No. 11) and are as follows:

	Per cent. dry matter.
Clover hay.....	88.63
Corn silage.....	20.90
Mangels.....	9.10
Wheat bran.....	88.10
Corn meal.....	85.00
Cotton-seed meal.....	91.80
Corn stalks.....	59.90
Oats.....	89.01

In this table and in the averages computed from it those months have been omitted in which the cow was dry for the whole or part of the time, and the figures therefore relate only to the milk given and the food consumed, during the time that the milk was given without reference to the food consumed when the animal was dry.

TABLE XII.—CONSUMPTION OF DRY MATTER IN WINTER MONTHS.

Cow.	Nov.	Dec.	Jan., 1-14, '93	Jan., 15-31, '92	Feb.	March.	April.	Total.
Beauty.....	—	724	309	411	743	800	767	3754
Belva.....	828	973	434	533	867	967	910	5512
Bertha.....	664	724	309	440	743	800	767	4447
Carrie.....	767	752	323	439	743	800	767	4591
Cora.....	—	—	—	—	752	800	767	2319
Daisy.....	557	721	309	440	743	800	767	4337
Freddie.....	828	973	434	569	973	1024	922	5723
Gazelle.....	—	687	309	—	—	800	767	2563
GemValentie.....	—	—	—	—	—	—	767	767
Glista.....	769	864	401	440	743	800	767	4784
Glista, 2d.....	—	752	323	440	743	800	767	3825
Jennie.....	681	724	309	—	—	—	767	2481
May.....	—	807	—	533	921	968	910	4139
Mollie.....	767	864	401	440	743	800	767	4782
Pearl.....	767	864	401	533	921	967	910	5363
Pet.....	828	—	—	—	—	893	910	2636
Puss.....	—	—	—	569	973	1024	942	3508
Ruby.....	—	864	401	525	911	968	910	4579
Shadow.....	*828	*971	—	*970	921	969	910	5569
Sue.....	*587	*889	—	*892	844	886	892	4990

* Figures for these two cows are for November and December, 1891, and the whole of January, 1892.

The averages of Table XII are summed up in Table XIII which gives the number of pounds of dry matter consumed for each pound of milk and fat yielded and also the pounds of dry matter consumed per 1000 pounds live weight per day. The average number of pounds of dry matter required for 100 pounds of milk was 104. Freddie required the least, 81 pounds, Daisy the

most, 249 pounds. The average number of pounds of dry matter required for 1 pound of fat was 27. Cora and Beauty required the least, 17 pounds; Glista 2d the most, 47 pounds. The average number of pounds of dry matter consumed per 1000 pounds live weight per day was 24.7. The standard for milch cows as given by Armsby (Manual of Cattle Feeding, p. 432) is 24. The larger cows required less per 1000 pounds live weight and the

TABLE XIII—DRY MATTER REQUIRED FOR ONE HUNDRED POUNDS MILK AND ONE POUND FAT.

Cow.	No of days.	Pounds dry matter consumed	Pounds milk produced.	Pounds dry matter consumed for each 100 lbs. milk.	Pounds fat produced.	Pounds dry matter consumed for each pound fat.	Live weight Lbs	Pounds dry matter consumed per 1000 lbs. live wt. per day.
Beauty..	152	3754	4728.00	79	225.55	17	858	28.8
Belva....	182	5512	6349.75	87	196.30	28	1326	22.8
Bertha..	182	4447	3280.50	136	162.03	27	946	25.8
Carrie...	182	4591	3092.25	148	108.93	42	972	25.9
Cora.....	90	2319	2528.50	92	133.95	17	1123	22.9
Daisy....	182	4337	1741.25	249	97.63	44	815	29.2
Freddie..	182	5723	7068.50	81	260.14	22	1474	21.3
Gazelle..	106	2563	2427.50	106	123.31	21	1071	22.6
Gem								
Valent'e	30	767	542.25	141	30.20	25	829	30.8
Glista...	182	4784	3903.25	123	134.13	36	1270	20.7
Glista 2d	152	3825	2736.00	140	82.13	47	1001	25.1
Jennie...	105	2481	1813.75	137	96.79	26	1030	22.9
May....	138	4139	3440.50	120	124.03	33	1283	23.4
Mollie...	182	4782	4743.75	101	153.72	31	1007	26.1
Pearl...	182	5363	5918.75	91	193.12	28	1160	25.4
Pet.....	91	2636	2795.00	94	95.71	28	1305	22.2
Puss....	107	3508	4743.00	74	140.36	25	1520	21.6
Ruby....	152	4579	4485.50	102	161.03	28	1183	25.5
Shadow..	182	5599	5340.75	104	242.89	23	1239	24.7
Sue.....	182	4990	5983.75	83	266.23	19	1040	26.4
Average				104		27		24.7

smaller cows more than the standard. Eleven cows, whose average weight was 1004 pounds, ate more than 24 pounds of dry matter per 1000 pounds live weight per day; 9 cows, whose average weight was 1267 pounds, ate less than 24 pounds of dry matter per 1000 pounds live weight per day, the extremes being 20.7 for Glista and 30.8 for Gem Valentine.

Heretofore no mention has been made of the breed of the various cows as it was preferred to discuss all of the questions bearing upon age, weight, etc., before taking up a discussion of the breed. Of the 20 cows 9 were grade Holsteins; 2 thoroughbred Holsteins; 6 grade Jerseys; 1 thoroughbred Jersey, and 2 common grade cows bearing evidence of having considerable Short Horn blood. The cows are grouped below:

Holsteins and Holstein Grades:

Belva.....	$\frac{3}{4}$
Carrie.....	$\frac{3}{4}$
Freddie.....	$\frac{3}{4}$
Glista.....	7857 H.F.H.B.
Glista 2d.....	2395 H.F.H.B.
May.....	$\frac{3}{4}$
Mollie.....	15-16
Pearl.....	$\frac{3}{4}$
Pet.....	$\frac{3}{4}$
Puss.....	$\frac{3}{4}$
Ruby.....	$\frac{3}{4}$

Jerseys and Jersey Grades:

Beauty.....	at least $\frac{3}{4}$
Bertha.....	at least $\frac{3}{4}$
Cora.....	at least $\frac{3}{4}$
Daisy.....	at least $\frac{3}{4}$
Gazelle.....	at least $\frac{3}{4}$
Gem Valentine.....	57881 A.J.C.C H.R.
Jennie.....	at least $\frac{3}{4}$

Common Grades:

Shadow.....
Sue.....

The percentage of blood in the Jersey grades is not definitely known because the foundation of the Jersey part of the herd was secured by purchasing some grade Jerseys that were known to be at least three-fourths bred, thus making their descendants at least seven-eighths bred.

In Table XIV we have grouped together the cows according to their rank in milk and butter production and according to their rank in the cost of milk and butter production prefixing the name of each animal with the letter belonging to its breed. It will be seen that the Short Horn Grades, particularly Sue, compared very favorably with the other breeds both in the amount and cost of production, but it is only fair to state that these two cows were the only two out of twenty of like breeding purchased at different times that it was thought advisable to keep in the herd for more than one year. It should also be stated in regard to them that they were farrow, and therefore undoubtedly continued to give a larger flow of milk for a longer time than though they had been due to drop calves again as the others did. As between the Jerseys and Holsteins it will be seen that they are pretty well sandwiched together as to relative rank. The Holsteins as a rule are better in the matter of the production of milk both as to amount and to cost, and the Jerseys stand better in regard to the production of

TABLE XIV.—RELATIVE RANKS.

Rank.	Relative rank in amount of fat pro- duced.	Relative rank in cost of fat.	Relative rank in amount of milk produced	Relative rank in cost of milk.
1	S. Sue	S. Sue.	H. Freddie	H. Pet.
2	H. Freddie	J. Beauty	S. Sue.	S. Sue.
3	J. Beauty	J. Cora.	H. Puss.	H. Puss.
4	S. Shadow.	H. Freddie.	H. Pet.	H. Freddie.
5	H. Pet.	H. Pet.	H. Belva.	H. Belva.
6	J. Cora.	S. Shadow.	H. Pearl.	H. Pearl.
7	H. Belva.	J. Gazelle.	S. Shadow.	J. Beauty.
8	H. Puss.	J. Jennie.	J. Beauty.	H. Mollie.
9	H. Pearl.	H. Belva.	H. Ruby.	H. Ruby.
10	J. Jennie.	H. Puss.	H. Mollie.	S. Shadow.
11	J. Gazelle.	H. Pearl.	H. Glista.	J. Cora.
12	H. Ruby.	H. Ruby.	J. Cora.	J. Gazelle.
13	H. Mollie.	H. Mollie.	H. Carrie.	H. Glista.
14	J. Bertha.	J. Bertha.	J. Jennie.	J. Jennie.
15	H. Glista.	J. Gem Val.	J. Gazelle.	H. May.
16	H. Carrie.	H. Glista.	H. May.	H. Carrie.
17	J. Gem Val.	H. Carrie.	H. Glista, 2d.	H. Glista, 2d.
18	H. May.	H. May.	J. Bertha.	J. Bertha.
19	H. Glista, 2d.	J. Daisy.	J. Gem Val.	J. Gem Val.
20	J. Daisy.	H. Glista, 2d.	J. Daisy.	J. Daisy.

fat both as to amount and cost; the order rank of the first ten being as follows:

In cost of fat, a grade Short Horn first, then two Jerseys followed by two Holsteins, next the other grade Short Horn followed by two Jerseys and then by two Holsteins.

In cost of milk, a grade Holstein first followed by a grade Short Horn, then four more grade Holsteins followed by a grade Jersey, then two grade Holsteins followed by the other grade Short Horn.

In Table XV the averages of the different groups and of the whole are shown. As between the Jerseys and Holsteins, the Jerseys were kept at a cost of about \$6.00 per year or thirteen per cent. less; they gave a little more than five-eighths as much milk and almost as much fat as the Holsteins; and produced the fat at a cost of two cents per pound less and the milk at twenty cents per hundred weight more than the Holsteins. The two grade Short Horns ate the most food, gave the most milk and fat, and produced milk and fat at the lowest cost, but for the reasons already shown they cannot be considered as types of the common

TABLE XV—AVERAGES BY BREED GROUPS FOR THE YEAR.

	Cost of food consumed.	Pounds of milk given	Pounds of fat produced.	Cost of 100 pounds of milk.	Cost of one pound of fat.
Two grade Short Horns	\$,1.23	9,705	411.07	\$.53	\$.125
Seven grade Jerseys....	40.87	5,237	269.67	.78	.15
Eleven grade Holsteins	46.95	8,067	272.96	.58	.17
Average of all..	45.25	7,241	285.62	.625	.158

grade cows of the country; they simply illustrate the fact that has often already been noticed that among such cows are to be found here and there individuals that will respond to good care and improved feeding in a most remarkable way.

In order to give the reader some idea of the general appearance of the cows we have had plates prepared from photographs of four of the best. At figure one is shown Sue, a grade Short Horn; she produced the most fat and next to the largest amount of milk. At figure three is shown Freddie, a grade Holstein; she gave the largest amount of milk and the second largest amount of fat. At figure two is shown Puss, also a grade Holstein, third in milk production, and at figure four Beauty, a grade Jersey, third in fat production. It is rather a remarkable coincidence that Puss and Beauty, respectively, ranked eighth in fat and milk production. These figures illustrate very nicely the fact that the scale and the fat tester are immeasurably in advance of any outward indication of the producing powers of a cow. Particularly is this shown in the cases of Freddie and Puss. Visitors, and indeed the men about the stable, almost invariably esteem Puss a better cow than Freddie; but the scale and fat tester have shown us that while Puss is not far below in milk, she is a long distance below Freddie in fat. Attention is also called to figure one. The position seems to be an unnatural and distorted one, but it is extremely life-like. This cow invariably stood in this cramped sort of a position and gave very little outward indication of her good producing powers.

SUMMARY.

Our records of this herd for the year seem to us to warrant the following conclusions :

First. With a fairly good herd, carefully fed and kept, milk can be produced for sixty-five cents per hundred weight and fat for sixteen cents per pound for the cost of food consumed.

Second. That individuals of the same breed vary more widely in milk and butter production than do the breeds themselves.

Third. The larger animals consumed less pounds of dry matter per 1,000 pounds live weight per day than did the smaller animals.

Fourth. That in general the best yields of fat were obtained from cows that gave at least a fairly large flow of milk, particularly as seen in the cows Sue, Freddie and Beauty.

Fifth. In general, the cows consuming the most food produced both milk and fat at the lowest rate.

Sixth. For the production of milk and fat there is no food so cheap as good pasture grass.

FERTILIZERS.

A great number of letters of inquiry have been received at this office regarding the value and application of farm and commercial manures ; as to their application for special purposes and also for some information regarding their profitable use on the various soils for the ordinary field crops. These letters not only show the interest the farmers of this state take in the questions of fertility and the appreciation of the importance of supplying plant food in some form but also a desire to become better informed as to the economical and profitable application of the plant food contained in the various farm manures or that purchased in the form of commercial fertilizers. An effort to explain some of the questions most frequently asked and to save the task of answering so many personal letters is the object of this short article.

Before we can make satisfactory comparisons of fertilizers, even though we have correct chemical analyses, it is necessary to adopt some uniform price for the various fertilizing constituents found in farm and commercial manures. The prices generally adopted for these purposes are those decided upon annually by Experiment Station Chemists of certain New England and Middle States. The average prices that these ingredients were sold for at retail in our larger cities for the previous six months determine the prices adopted for the year. The following is a list of prices for 1892. These will not differ materially from the prices for 1893 :

FERTILIZERS—TRADE VALUE FOR 1892.

Nitrogen in ammoniates.	\$.175
Nitrogen in nitrates.....	.15
Organic nitrogen in dry and fine ground fish, meat and blood	.16
" " cotton-seed meal and castor pomace.....	.15
" " fine ground bone and tankage.....	.15
" " " " medium bone and tankage.....	.12
" " medium bone and tankage.....	.095
" " coarser bone and tankage	.075
" " hair, horn, shavings and coarse fish scraps	.07

Phosphoric acid soluble in water.....	.075
“ “ “ ammonia citrate (reverted).....	.07
“ “ “ in dry ground fish, fine bone and tankage.....	.07
“ “ “ fine medium bone and tankage.....	.055
“ “ “ medium bone and tankage.....	.045
“ “ “ coarser bone and tankage.....	.03
“ “ “ insoluble in complete fertilizers	.02
Potash as high grade sulphate and in forms free from muriates or chlorides	.055
Potash as kainit.....	.045
Potash as muriate.....	.045

Following is given the guaranteed analyses of a brand of fertilizer sold in this state to which the foregoing prices will be applied to ascertain the value of the plant food contained in this particular brand :

GUARANTEED ANALYSES.

Ammonia	1 to 2 per cent.
Soluble phosphoric acid	8 to 10 “
Reverted phosphoric acid.....	2 to 3 “
Available phosphoric acid	10 to 12 “
Insoluble phosphoric acid	1 to 3 “
Total phosphoric acid.....	11 to 15 “
Sulphate of potash	2 to 4 “

Of these constituents, the nitrogen contained in the ammonia, the soluble, reverted and insoluble phosphoric acid, together with the potash, constitute the valuable plant food. As these constituents in analyses are given in per cent. or by the hundred the number of pounds of each constituent in a ton may be ascertained by multiplying the per cent. by 20.

Ammonia is $\frac{1}{4}$ nitrogen.

Sulphate of potash is $\frac{1}{4}$ actual potash.

The following is an application of the prices given to the foregoing guaranteed analysis. The lowest per cent. guaranteed is always taken for computation.

Ammonia 1 per cent. $\times 20 \times 14$ divided by 17 gives 16.47 lbs. of nitrogen in one ton ; 16.47 multiplied by 16 cents gives	\$ 2.64
Soluble phosphoric acid 8 per cent. $\times 20 \times 7\frac{1}{2}$ cents per lb. gives	12.00
Reverted phosphoric acid 2 per cent. $\times 20 \times 7$ cents per lb. gives.....	2.80
Insoluble phosphoric acid 1 per cent. $\times 20 \times 2$ cents per lb. gives.....	.40
Sulphate of potash 2 per cent. $\times 20 \times 47$ divided by 87 and multiplied by $4\frac{1}{2}$ cents per lb. gives.....	.97
Total value per ton.....	\$18.81

To this amount should be added something for freight, mixing and commissions.

The application of these prices is intended to afford a means for comparing the value of plant food derived from different sources rather than the producing value of any particular brand of commercial fertilizers.

In a general way the following rules may be of some aid in applying plant food under ordinary conditions.

Reclaimed lowland rich in vegetable matter is likely to be rich in nitrogen but deficient in phosphoric acid.

Well drained highland, particularly on exposed locations, is more likely to be deficient in nitrogen than phosphoric acid.

Where crops have made a small growth of leaf or stalk, under otherwise favorable conditions, nitrogen is likely to be deficient in the soil.

A large yield of plump, bright grain from a small or moderate growth of straw or stalks would indicate an abundance of phosphoric acid and potash and a deficient amount of nitrogen.

An abnormal growth of leaf or stalk with a small yield of light grain would indicate an abundance of nitrogen and an insufficient amount of phosphoric acid and potash.

As a rule, plants having the greatest leaf development require the most potash.

Farm manures that have been well cared for contain about twice as much nitrogen as phosphoric acid, and consequently land that has received recent liberal applications of barn manures is not likely to be deficient in nitrogen.

High grade fertilizers generally give more plant food for their cost than those of low grade.

Pure sodium nitrate (Chili saltpetre) in 100 lbs. contain 16.5 lbs. of nitrogen.

Pure ammonium sulphate in 100 lbs. contains 21.2 lbs. of nitrogen.

Pure chloride or muriate of potash in 100 lbs. contains 63.5 lbs. of actual potash.

Pure sulphate of potash in 100 lbs. contains 54 lbs. of actual potash.

Kainit should contain in 100 lbs. about 12 5 lbs. of potash.

The best results from sodium nitrate are secured by frequent applications of small amounts on the growing crop as a top dressing.

GEORGE C. WATSON.

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Cornell University Agricultural Experiment Station.

BOTANICAL DIVISION.

Edema of the Tomato.



By GEO. F. ATKINSON.

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Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1893.

50. The Bud Moth.
51. Four New Types of Fruits.
52. Cost of Milk Production.—Variation in Individual Cows.
53. Œdema of the Tomato.

CEDEMA OF THE TOMATO.

During the latter part of October, 1892, tomato plants, of a variety No. 18, grown in the forcing houses of the Horticultural Department, presented a very peculiar appearance. The plants were at some little distance from the main passage way in the tomato house through which I occasionally passed. For this reason, and also because no complaint was entered by the growers, the trouble escaped my notice. The plants presented to me the appearance of having been recently transplanted, many of the compound leaves having a curved pendent position, though the leaflets were usually curved strongly upward, showing the lighter color of the under surface. It was suggested at that time that this peculiar position of the leaf and curl of the leaflets was a peculiarity of the variety. Upon each of several following visits to the forcing house, at intervals of four to six days, the peculiar appearance of these plants fastened my attention for a few minutes. Upon one visit I had occasion to pass the bench upon which they were growing, and could not resist the impulse to look more closely at the character of the curled leaf.

It was at once apparent that this peculiar appearance was not normal to the plant. The veinlets as well as the midrib, petioles, and the surface of the stem presented numerous elevated areas of a frosty aspect as shown in figures 1 and 2, in Plate I. Their resemblance to masses of conidia formed in the early stages of some of the *Erysipheæ* was very striking. Examined with a pocket lens a mass of minute rounded bodies could be seen which still bore some resemblance to conidia of the powdery mildews. The rounded particles possessed a gleaming aspect and did not lie so loosely nor appear in chains as is the case with these mildews. A little further observation showed that great injury to the plant followed in the latter phases of the trouble.

It was quite natural before recourse to a microscopic examination to attribute the mildewed aspect of the leaves and the dying of the leaves in the later stages to the operation of some fungus. But a section through one of these areas revealed under the

microscope a very different state of things. The affected areas had the appearance of a cushion similar to an erinoid or hypertrophied condition of the tissue. The epidermal cells were very much enlarged while the chlorophyll bearing cells just beneath as well as some of the more deeply seated cells were greatly elongated in a radial direction, and strongly clavate at their outer extremity where this extended beyond the lateral pressure from adjacent tissue. In many cases the epidermal cells quickly separate and slough off. The cells of the affected areas possessed exceedingly delicate walls so that with little disturbance they would collapse. There was little protoplasm in proportion to the size of the cell and a corresponding amount of cell sap.

Several of the notable phenomena coincident with the development of these cushions of abnormally turgescient tissue are explained by this peculiar physical derangement of the normal cell structure. The frosted or whitened aspect of the cushions results from the small amount of chlorophyll in proportion to the leaf surface. The amount of chlorophyll in the individual cell remains the same while the grains are far separated in their distribution throughout the greatly enlarged cell. The curling upward of the leaves results from the greater lateral pressure which exists in the cells of the lower surface of the veins.

A comparison of the normal tissue with that of the cushions will serve to show the profound changes accompanying their development. From serial sections made through several of these cushions on the leaf veins two sections were selected from one series to illustrate the changes in this part of the leaf. Camera lucida drawings were made from these two sections magnified to the same scale. One of these represented in figure 4 was taken from the leaf vein just before the series of sections entered the cushion and practically represents the normal arrangement and form of the cells of the leaf vein. Figure 5 represents one of the serial sections of the same leaf vein, the section having been taken from the center of the cushion. Each end of the section at *a* represents relatively the normal condition of the cells of the leaf. The line of epidermal cells, *e, e*, is still adhering for some distance, but at the summit of the cushion they have fallen away. A comparison with the normal epidermal cells shows how much they have been enlarged. The sub epidermal cells have undergone

the most profound change, being eight to ten times their normal size. Some of the deeper lying cells have also elongated radially, while others have become abnormally enlarged. It will be observed that the distention of the cells has not only profoundly changed their normal form, but the crowding one upon another has displaced many others. A study of the series of sections from such a cushion, as well as the study of one in an early stage of development, shows that the epidermal cells nearly always first partake of the radial elongation. These are followed by the sub-epidermal layer and so on.

Serial sections through the cushions on the stem were also made. Three from a series through quite a young cushion on the stem are reproduced by camera lucida drawings in figures 9, 10 and 11.

Figure 9 represents a section taken from the edge of the cushion and shows the early stage in the elongation of a few epidermal cells. In this section is also shown a peculiarity in the early elongation of some of the more deeply seated cells. A few of the cells of the collenchyma have elongated radially before those lying immediately outside of them have changed their form. This rarely occurs, and by the time the sections approach the center of the cushion the successional changes of the layers of cells from the outside exists in the usual manner. It is to be noted in connection with the elongation of the cells of the collenchyma, that while such thick-angled tissue offers support to the stem, little more resistance is offered to the radial elongation of the cells by this tissue than by parenchyma. The lateral walls being thin permit the cell membrane to be stretched. Figure 11 is one of the series from the center of this very young cushion. Figure 12 is from an older cushion on a much older part of the stem of the same variety. Here many of the epidermal cells have sloughed off and others are nearly free. The hypodermal layer, chlorophyll bearing layer, is remarkably elongated, while the first layer of the collenchyma is also changed. In the older cushions the radial elongation effects also deeper layers of the collenchyma, sometimes two or three layers. Usually by the time such changes occur to any marked degree in the deeper layers, the sub-epidermal portion of the cushion is in a state of collapse. This effect is partially shown in figures 13 and 15.

On the leaves of some plants there frequently is very little evidence to the unaided eye of the presence of these cushions. But here and there, upon close examination, can be seen very minute elevations. Magnified with a pocket lens they present the appearance shown in figure 6. They appear to be located entirely in the mesophyll of the leaf, or more properly speaking, at or near the terminations of some of the veinlets. This probably accounts for their small size. Being located in such delicate tissue they rapidly collapse and disappear from view.

Figures 7 and 8 represent sections selected from serial sections through one of these small mesophyll cushions. Figure 7 is taken from the edge and shows the remarkable enlargement of two of the epidermal cells. Near by can be seen the termination of a vascular bundle. Figure 8 is from the center of the same mesophyll cushion. Passing from each end of the section toward the center an idea can be formed of the progressive elongation of the different cell layers. The tissues at the summit of the cushion are in a state of collapse. This one is remarkable from the fact that the elongation has advanced from the epidermal layer of the under side of the leaf through the parenchyma until the palisade cells of the upper side of the leaf are concerned, and their elongation is in the same direction, *i. e.*, toward the lower side of the leaf. This results from the fact that the progressive elongation, beginning at the lower side of the leaf and advancing toward the upper, has relieved the pressure from adjacent cells on the lower side, and also that the primary enlargement of the cells of the under side caused the leaf, at this point, to arch downward, which in itself would make the lower side of the cells the point of the least resistance. Figures 6, 7 and 8 are from plants sent by L. R. Jones, Horticulturist of the Vermont Station. Very rarely, I have noted in a few instances in the forcing house, cushions are formed upon the upper side of the leaf.

The primary effects of this derangement of the tissue, farther than is pointed out above, relates to certain interferences with the life and nutrition of the plant which are manifestly attributable to it. When the cell walls have become so inordinately stretched that they suddenly collapse, as frequently happens, the changes brought about by the escape of water from this and adjacent tissues during the warmer part of the day may be so profound as

to cause the leaf to wilt and die. In other cases, the cushions when collapsed soon dry without great loss of water from adjacent tissues, but the injury is so deep it seriously disturbs the nutrition of that part of the leaf as shown by a yellowing of the upper surface at this point. Numerous points of attack on the venation of the lower surface of the leaf in such cases gives to the upper surface a spotted appearance, while the dried cushion immediately below presents a tomentose appearance. Although in such cases the entire leaf is usually curled upward, the points of injury are more strongly arched, which produces upon the upper surface of the leaf a depressed area within the yellow spots.

The secondary effects of the trouble relate to profound changes which sometimes follow, but which are not so manifestly attributable in all cases, at first examination, to this derangement of the tissues. Frequently, when the leaf does not wilt after the collapse of the cushion, the broken and dying tissues encourage the development of putrefactive germs which set up fermentations that affect adjoining tissues and the leaf is slowly disorganized. Discoloration of the tissue accompanies these morbid phenomena, and while they proceed also through the very succulent parenchymatous tissue of the petiole and down the stem, there appear elongated, depressed, blackened areas, which eventually reach the vascular tissue of the stem.

Frequently such morbid changes originate from cushions developed on the stem, and there is reason to believe that sometimes quite extensive areas of hypodermal tissue of the stem are stretched enormously and induce similar destructive metabolism when the epidermis has become too firm for its individual cells to participate in such change.

When the development of the cushions is confined mainly to the mesophyll areas of the leaf, or to the very small veinlets, or at their terminations, they rapidly collapse and the morbid changes succeeding in the mesophyll extend over areas of various sizes, which in the early stages are yellowish in color. In these secondary effects many of the very small young leaves are affected at the apex, frequently the entire apex being involved, and on the somewhat larger leaves it may be confined chiefly to the base of the leaf, or the severity of the attack is located there. The progress of this yellow color indicates failing nutrition which is

augmented by the interference produced from the diseased areas in the stem. It terminates in the death of the tissues involved, which then change to a dirty greyish brown color. The veinlets involved become much darker in color, being nearly black, so that viewed through a pocket lens the greyish brown patches show frequently cross lines of black or borders of the same color.

Inquiry into the governing cause. Having observed the external aspect and progress of development of these cushions, as well as their minute anatomy and relation to the well being of the plant, the inquiry into their cause presents itself. The existence of any fungus of ordinary dimensions standing in causal relation was easily disposed of. Their superficial resemblance to the erineum developed on the leaves of various species of birch, maple, alder, etc., through the stimulus induced by irritation from phytoptid mites, suggested a similar symbiont upon the tomato plant. But careful examination proved this suspicion to be groundless.

By this process of elimination of suspected causes, the enquiry was gradually removed from the region of the possible symbiosis of some one of the more prominent and easily recognizable microscopic forms to that of the possible relation of some form of bacteria which, by its presence within or upon the affected organs, excited them to this abnormal development.

Two lines of investigation were carried out, having in view the discovery of the causal germ. One of these proceeded upon the more customary, but less scientific, lines of enquiry usually adopted in the study of the bacteria of plant diseases, viz.: the inoculation with diseased material; the other proceeded upon the more rational line of enquiry chiefly adopted in the study of the bacteria of animal diseases, viz.: the separation of the germs present and inoculations with pure cultures to determine the specific germ.

Inoculations of healthy plants with diseased material. Experiment No. 1, December 3, 1892. Macerated tissue from freshly developed cushions was gently rubbed between the thumb and finger upon the leaves and stem of a healthy plant. Portions

of the affected plant were also left pendent upon the healthy one. *No result.*

Experiment No. 2, December 3, 1892. Macerated tissue from a plant in the later stages of disorganization was gently rubbed between the thumb and finger upon the leaves and stem of a healthy plant. A portion also of the diseased plant was left pendent upon the healthy one. *No result.*

Experiment No. 3, December 3, 1892. Twenty very young plants freshly potted, just developing the plumule, were treated as follows: There were four rows, five plants in each row. To one plant in each row was applied some of the macerated tissue from freshly developed cushions. Likewise to one plant in each row was applied some of the macerated tissue from a plant in the later stage of the disease. *No result.*

Experiment No. 4, December 3, 1892. In a potted plant were made several slit wounds with a scalpel, parallel with the axis of the stem and petiole. Into these were introduced thin longitudinal slices of tissue from freshly developed cushions. The wounds were then wrapped with fresh tomato leaves and tied loosely to prevent too great evaporation from the wound. The plant was thoroughly sprayed with water also. *No result.*

Experiment No. 5, December 3, 1892. In like manner a potted plant was inoculated with longitudinal slices from a stem in the later stages of the disease. *No result.*

Separation of bacteria from affected plants. By the use of sterilized instruments and with precautions against contamination from the outside, portions of the interior of freshly developed cushions were transferred to nutrient agar which contained an infusion of tomato plant. *No growth appeared.*

Portions of the cushions including the external parts were then macerated in sterilized distilled water, and the dilution was farther diluted in the usual way in three tubes of liquid nutrient agar containing tomato plant infusion. Esmarch rolls and cultures in Petrie dishes were made of these, and several different bacteria were isolated.

In like manner leaves of plants in the later stages of the disease were macerated and carried through dilutions to isolate bacteria. Also tissue from the internal parts of petioles and stems in the later stages of the disease were used for dilution cultures.

From several such dilution cultures there were obtained fifteen different species of bacteria which were grown in pure cultures and used for inoculations. Of these there were three species of *Bacillus*, three of *Micrococcus* and the remainder probably species of *Baflerium*. One *Micrococcus* and four species of *Baflerium* were chromogenous forms. The chromogenous forms and one species of *Bacillus* (*B. figurans*) were not considered suspicious, but it was very little additional trouble to carry on cultures of these.

When the organisms were isolated they were grown in quantity in a liquid culture consisting of equal parts of bouillon and tomato plant infusion.

Experiment No. 6, December 19, 1892. Inoculations were made with liquid cultures of the bacteria as follows: The liquid containing the cultures was gently rubbed between the thumb and finger upon the surface of the stem and leaves. Also with a needle abrasions were made of the surface tissue of petioles and stems introducing in this manner into the superficial tissues some of the organisms. *No result.*

The entire series of inoculations was made in such a way that several duplicate inoculations were made of all the germs present which could possibly bear any relation to the trouble. The negative results point to the possibility that there is some disturbance of the equilibrium of the natural forces and physiological processes in the plant. This suspicion is strengthened by the fact that the cushion is not formed by ordinary hypertrophy which is accompanied by increase of nutriment at that point, and multiplication of cells. Ordinarily, there is no increase in the number of the cells. When this does occur it takes place in the deeply seated cells which do not suffer collapse while the more superficial ones break down. The increase in the number of cells in such cases occurs simply by the formation of transverse walls in the elongated cells.

Is the trouble a physiological one? The abnormal stretching of groups of cells to eight to ten times their normal size would then be sought for in the excessive activity of one or more of the physiological processes which contribute to turgescence and in the lesser activity of those processes which relieve it.

The most important of these seems to be the excess of root

pressure over transpiration. It will be instructive to consider the conditions of environment which have united to disturb the desirable stability of equilibrium of these two forces in the plant.

The close confinement of the plants in the forcing house where there is little agitation of the air, must necessarily lessen the rapidity and amount of transpiration compared with what would take place in the open. The water vapor freed through transpiration from plants grown in the open under natural conditions is quickly carried away by currents of air* which are to a greater or less extent in almost constant action. This permits then a more active transpiration than could take place should the water vapor remain undisturbed near the foliar organs. Even should the water vapor escape from the neighborhood of the transpiring surfaces only through the law of diffusion plants in the open would be at a greater advantage than those grown in the confined quarters of the forcing house. That transpiration is obstructed by the humidity of the atmosphere has been abundantly shown.†

* Sachs Physiology, p. 554.

Höhnel, Ueber den Gang d. Wassergehaltes und Transpiration bei Entwicklung d. Blattes, 1878. Cited by Pfeffer, p. 144.

Wiesner, Grundversuche ueber den Einfluss der Luftbewegung auf die Transpiration. Bot. Centralb., viii, pp. 382-383.

Wind according to Wiesner in most cases accelerates transpiration. In some cases (*Saxifraga sarmenlosa*) it closes the stomates and therefore retards transpiration. See same title in P. A. Wien, Abth. i, Bd. xcvi, pp. 182-214. Cited in Just's Bot. Jahrbücher, 1888, 1, pp. 83-84.

† Unger, Sitzungsbericht d. Wiener Akademie, Bd. xlv, 2, 1861.

Sachs, Handbuch der Experimental-Physiologie, 1865. Sitzungsab. d. Wien. Akad. Bd. xxvi.

Déherain, Comptes Rendus, T, lxi.

Masure, Untersuchungen über die Verdunstung des freien Wassers, des im Ackerbodenenthaltene Wasser, und über die transpiration der Pflanzen, Ann. Agronomiques, T, vi, fasc. iii, pp. 441-500.

Reinitzer, Ueber die physiologische Bedeutung der Transpiration der Pflanzen. Sitzungsberichte der K. K. Acad. d. Wissenschaft, 1881, 1, Abth.

LeClerc, De la transpiration dans les végétaux, Ann. d. Sc. Nat. T, xvi, 1883, pp. 231-279.

Tschaplowitz, Gibt es ein Transpiration-Optimum? Beitrag zur Theorie der Vegetationsconstanten Bot. Zeit., Jahrg. 41, No. 22, S. 353-362.

Kohl, Die Transpiration der Pflanzen, etc., Braunschweig, 1886.

Eberdt, Die Transpiration d. Pflanzen und ihre Abhängigkeit von äusseren Bedingungen, Marburg, 1889

Goodale, Physiological Botany.

Transpiration is less active during the night than in the day, not only because of the lower temperature of the air, but especially because of the absence of light.* During the winter season when plants are grown in the forcing houses the nights are much longer than the days and the total amount of transpiration in 24 hours, other things being equal, would be less than what would take place in the open during the summer months when the days are much longer than the nights. Add to this the marked number of cloudy days during the winter, with a low sun offering at best but a feeble light, and the conditions for transpiration are still more unfavorable.

Still another factor must be considered which deprives the plants of much light, the structure of the forcing house itself. The light is not so intense when it passes through glass, though the amount of light thus cut off may be very little. However, the frame work, walls and partitions do cut off an appreciable amount of light.

These considerations, showing a lessened amount of transpiration compared with what takes place under natural conditions when the plants are grown out doors, would place root pressure in excess of transpiration should the conditions for root pressure under both circumstances be the same.

With the comparatively small amount of light carbon assimilation is lessened, so that the plant under the forced conditions of growth, when it needs larger quantities of carbohydrates has to do with really a less quantity than is supplied in the open where conditions for rapid growth are not so favorable and those for assimilation are improved.

***Sach's Physiology.**

Goodale, *Physiological Botany*.

Unger, *Sitzungsb. Wien. Akad.* Bd. xliv, 2, 1861.

Déherain, *Compt. Rend. Paris* T. lxix.

Masure, *Ann. Agronomique*, T. vi, fasc, pp. 441-500.

Reinitzer, *Sitzungsb. d. K. K. Acad. Wiss.*, 1881, I.

Leclerc, *Ann. Sci. Nat. Bot.* T. xvi, 1883, pp. 231-279.

Kohl, *Die Transpiration der Pflanzen*, Braunschweig, 1886.

Eberdt, *Die Transp. d. Pfl. u. ihre Abhäng. v. aus Bed.* Marburg, 1889.

Burgenstein, *Material zu einer Monographie der Transpiration*, *Verhandlungen d. K. K. Zool. Bot. Gesellsch.* Zu Wien Vol. 37, 1887, pp. 691-782, and Vol. 39, 1889.

Soil temperature compared with that of the air. Some observations made upon the temperature of the soil and air in the tomato house indicate that the soil is maintained at a temperature only a few degrees below that of the air. A sufficient number of observations have not been made to show what bearing the difference in temperature between the two media has upon the relation of root pressure to transpiration. At the lower benches (those at the side of the house where the glass is quite close to the beds) the soil, from a few observations, possessed a temperature of 2° to 5° Fahr. lower than the air, while in the center of the house,

TABLE OF COMPARATIVE SOIL AND AIR TEMPERATURES,
(FAHRENHEIT.)

		7 A. M.	1 P. M.	7 P. M.	MEAN.
May, 1891	Inches.				
	Air.....	47.04	61.75	53.30	54.04
	1 Soil.....	46.54	54.03	52.93	51.17
	3 Soil.....	54.31	53.73	52.87	53.63
	6 Soil.....	47.49	49.27	51.24	49.33
	9 Soil.....	47.83	48.22	49.36	48.80
	12 Soil.....	47.64	47.63	47.90	47.72
	24 Soil.....	45.00	45.14	45.20	45.10
	36 Soil.....	43.78	43.49	43.50	43.59
	Mean of Soil.....	45.47	46.40	46.45	46.10
June, 1891	Air.....	58.28	72.42	65.38	65.36
	1 Soil.....	59.18	65.42	64.53	63.04
	3 Soil.....	59.10	64.80	64.21	62.70
	6 Soil.....	59.43	60.40	61.73	60.52
	9 Soil.....	59.23	58.96	59.67	59.28
	12 Soil.....	58.79	58.37	58.60	58.58
	24 Soil.....	54.00	54.12	54.11	54.07
	36 Soil.....	51.25	51.35	51.37	51.32
	Mean of Soil.....	54.80	55.68	55.74	55.40
July, 1891	Air.....	64.08	76.05	68.81	69.65
	1 Soil.....	62.70	68.59	67.44	66.24
	3 Soil.....	62.78	67.56	67.10	65.81
	6 Soil.....	63.08	64.23	65.18	64.16
	9 Soil.....	63.17	63.18	62.85	63.07
	12 Soil.....	62.39	62.14	62.44	62.32
	24 Soil.....	58.16	58.25	58.26	58.22
	36 Soil.....	55.75	55.82	55.82	55.79
	Mean of Soil.....	58.91	59.73	59.69	59.44

where there was an opportunity for the warm air to rise toward the ridge, the difference in soil and air temperature was greater, being more marked the higher the elevation at which the temperature was taken in the air.

In the absence of careful data covering a period of several weeks there could not be made any satisfactory comparison with the difference between soil and air temperature out doors during the growing months. However, it will be interesting to note such differences in this connection. For this reason there is appended here a table of soil and air temperatures adapted from data published by President Fernald of the Maine Agr. Exp. Station.*

The difference in the mean temperature of the soil (from 1-36 inches) and air for May, June and July is thus seen to be approximately 10° Fahr. Comparing the temperature of the soil from 1-12 inches it is found to be from 5°-6° Fahr. below the mean temperature of the air. It is doubtful, however, if these temperatures taken only at the stated times of day really give the information desired in relation to the bearing of soil and air temperatures on root pressure and transpiration. For through the day when the temperature is the highest that of the air is still higher and with the aid of light and agitation of the air transpiration is sufficient to relieve the plant. The early period of the night is the time when out doors the conditions for root pressure as indicated by temperature would be more favorable than they would for transpiration. But terrestrial radiation soon lowers the temperature of the soil so that the plants exist under this disadvantage a comparatively short time.

Here again it is necessary to bear in mind the very short nights during which transpiration is low in comparison with the long days when it is very active. The light conditions are reversed in the forcing house and frequently the light is very feeble with little agitation of the air while there is a continued maintenance of soil temperatures suitable for active root absorption. Thus while it cannot be asserted positively that the temperatures of the forcing house are such as to add to the complex disturbance of

*Annual Report, Part IV, Maine State College Agr. Exp. Station, pp. 155-174.

the physiological processes, there are indications that such is the case.

Since turgescence is mainly dependent upon root absorption for the supply of water and a turgid condition of the plant soon follows strong root pressure unless transpiration is taking place rapidly, it has become customary to say that root pressure causes turgidity. Of course, it is understood that this is not the immediate cause. Water cannot be pressed into a cell and cause turgescence. The cell wall is permeable and as rapidly as water could be driven in at one side it would filter out at the other. The protoplasmic utricle* which lines the cell wall is not permeable, or at least only to a small degree. The water, then, which passes into the cell through the protoplasmic utricle, cannot filter out, and when it does not escape by evaporation or exosmose from the surface, it stretches the protoplasmic utricle, presses it against the elastic cell wall which then yields and the cell is turgid. The extent to which the cell wall is stretched depends upon the endosmotic activity which introduces water into the cell, the rate of transpiration and the firmness of the cell wall. The endosmotic activity within the cell is brought about by the presence of certain salts or organic acids in the cell sap which have a strong affinity for water.†

By root absorption the plant is supplied with water, the permeable cell wall permitting it to flow from the vascular bundles into the fundamental and other tissues where it comes in contact

*Mohl. Bot. Zeitung, 1846, p. 75.

Nægeli, Pflanzenphysiologische Untersuch. Heft I, 1855, p. 1.

Pfeffer, Osmotische Untersuchungen. Leipzig 1877.

Sachs' Physiology.

Goodale, Physiological Botany.

†De Vries, Ueber die Ausdehnung wachsender Pflanzenzellen durch ihren Turgor, Vorläufige Mittheilung; Bot. Zeit. 1877, S., 1-10.

Untersuchungen über die mechanischen Ursachen der Zellstreckung von der Einwirkung von Salzlösungen auf den Turgor wachsenden Pflanzenzellen, Leipzig, 1877. See Justs Bot. Jahreshb. 1877, I, p. 65-67.

Ueber die Bedeutung der Pflanzensäuren für den Turgor der Zellen. Bot. Zeit. 1879, p. 847.

Palladin, Athmung und Wachsthum, Berichte d. Deutsch. Bot. Gesellschaft, 1886, pp. 322-328.

Bildung der organischen Säuren in den wachsenden Pflanzentheilen, Ber.d. Deuts. Bot. Gesellschaft, 1887, p. 325.

with the protoplasmic membrane lining the cell wall. When root absorption is active and transpiration is inactive or at a low ebb, the affinity which the vegetable acids possess for the water draws it within the cells. Root absorption practically being in operation continuously under the conditions of the forcing house, and transpiration being in operation for such a large part of the time, the cell walls are unduly stretched. This continues until a point is reached where the normal tissue tension is overcome and the fundamental tissue of the leaf or the cortical parenchyma of the stem is no longer held in longitudinal tension. The cell wall thus continuing to stretch yields at the point of least resistance which is at the surface of the congested tissue and the radial elongation of the cells is the result.

The organic acids increase most rapidly at a temperature ranging from 50° to 57° Fahr.* As the temperature rises above this point they are gradually decomposed. Darkness or weak light also favors their increase and De Vries† has shown that a periodicity of increase or decrease of these acids exists corresponding to night and day. In fact anything which interferes with oxidation serves to permit their increase while those conditions which promote oxidation serve to decrease them.‡ According to Warburg it is not the direct action of light which decomposes these organic acids but the oxygen set free during carbon assimilation.||

Another effect of the feeble light and its short duration is the proportionately small quantity of carbohydrates produced. Except in the case of some shade plants where direct solar light may be too intense for normal assimilation, other things being

*De Vries, Ueber den Antheil der Pflanzensäuren an die Turgorkraft wachsender Organe. Bot. Zeit. 1883, S. 850.

Warburg, Untersuchungen aus d. Bot. Inst. 2. Tübingen, Vol. 2. Heft I, 1886, p. 71.

†De Vries, Ueber die periodische Säurebildung der Fettplanzen, Vorläufige Mittheilung, Bot. Zeit., 1884.

Ueber die Periodicität im Säuregehalt der Fettplanzen, Verslagen en Mededeelingen der Koninkl. Akad. van Wetenschappen, Afd. Naturkunde, R. P. Amsterdam, 1884.

‡Ward. On some Relations between Host and Parasite. Proceedings Royal Society, Vol. 47.

||Warburg, Untersuchungen, etc., pp. 77-92.

equal, the activity of carbon assimilation increases nearly in proportion to the intensity of solar light,* or as the plants exist under more favorable conditions of light. Wollney shows that the water content† is less and the quantity of carbohydrates greater the better the plants are lighted.

One reason why shade plants when exposed to the direct light of the sun may be injured is because the form and structure of the leaves developed in the shade is different from that of plants in sunny places as shown by Stahl.‡ Grosz§ has proved experimentally that such difference is a natural adaptation to environment.

Obstructed transpiration in conjunction with strong root pressure produces much the same condition of tissues as is found in etiolated plants. Ward says,|| "we may look on a shoot

*Wolkoff. Einige Untersuchungen über die Wirkungen des Lichtes von verschiedener Intensität auf die Ausscheidung der Gase durch Wasserpflanzen. Pringsheim's Jahrbücher, Bd, 5, S. 1-30.

Van Tieghem, Respiration des plantes submergées à la lumière d. une bougie, lieu de formation des gaz. Comptes Rendus. herbd. 1869, p. 482.

Famintzin, Die Wirkung des Intensität des Lichtes auf die Kohlensäurerzersetzung durch Pflanzen, Bulletin de l'Acad. d. St. Petersburg, Vol. 26, 1880, column 296-314.

Pringsheim, Zur Kritik der bisherigen Grundlagen der Assimilationstheorie der Pflanzen, Monatsberichte der Berliner Academie, vom Feb., 1881, S. 15 und 16, cited by Reinke, Bot. Zeitung, 1883, No. 42, 43 and 44.

Ward, Proceedings Royal Society, Vol. 47.

Sachs' Physiology.

Pfeffer Pflanzenphysiologie.

Detmer Lehrbuch der Pflanzenphysiologie.

†Wollney, Beiträge zur Frage des Einfluss des Lichtes auf die Stoff- und Form-bildung der Pflanzen. Forsch. Agr. Bd. vii, 1884. pp. 351-375, cited in Just's Bot. Jahresbericht, 1884, i, pp. 30-31.

‡Ueber den Einfluss des sonnigen oder Schattigen Standortes auf die Ausbildung der Laubblätter, Zeitschrift für Naturw. xvi, n. f. ix, 1, 2. Cited in Bot. Zeitung, 1883, s 330, and Just's Bot. Jahresbericht, 1883, ii, pp. 425-426.

§Bot. Centralb. 1884, No. 51, pp. 374-378. Just's Bot. Jahresb. 1884, i, p. 28.

||On some Relations between Host and Parasite. Proceedings Royal Society, Vol. 47. pp. 393-443.

See also Vesque et Viet. Influence du Milieu sur les végétaux, Ann. de Sci. Nat. 6th Series, Bot. Vol. 12, 1891, p. 167.

growing in a saturated atmosphere as presenting all the chief features of one growing in darkness. Its cells are extremely turgid, with watery, soft, thin walls,* and acid cell-sap; its vascular bundles feebly developed and hardly lignified; and as before it is ill adapted to withstand the exigencies of the ordinary environment."

Thus obstructed transpiration in the forcing houses through feebleness and short duration of light, and an atmosphere more humid than the average in the open during the summer months favors watery tissue, thin cell walls which are easily stretched and rapid growth in size. The weakness of the cell walls is increased through lack of sufficient building material, a result of the low degree of assimilation.

During certain processes of destructive metabolism, brought about by respiration, nitrogenous compounds like asparagin, leucin, etc., are built up. When an abundance of carbohydrates are present in the protoplasm the amides are worked up into more complex bodies. When there is a lack of carbohydrates the amides increase and the protoplasm suffers from farther decomposition.†

The simultaneous increase of the organic acids tends to overcome the tension of the protoplasm which should hold them in bounds, and they gradually diffuse through it. This may continue until the protoplasm is killed by the increase and diffusion of these substances.

This study of the environment of the plants under these conditions of forced culture and the operation of the natural forces and physiological processes leads irresistibly to the conclusion that this affection of the tomato plants is a physiological one.

Confirmed by Experiment. In order to test the effect of the

*Similar results have been obtained by students in Physiological Botany at Cornell University. Bean plants grown with lessened degrees of diffused light show corresponding grades of approach to etiolated plants and also corresponding degrees of frail, succulent tissue.

†Schulze, *Landwirtschaftliche Jahrbücher*, 1876, Bd. 5, p. 848.

Bonordin, *Bot. Zeitung*, 1878, p. 801, cited by Ward, *Proceed. Royal Soc.*, Vol. 47, pp. 343-443.

Palladin, *Ueber Eiweisszersetzung in der Pflanzen*, *Ber. d. Deutschen Bot. Gesellschaft*, 1888, p. 205.

Pfeffer, *Pflanzenphysiologie*, p. 301.

injection of excessive amounts of water into the plant the following experiment was carried out.

On Monday, December 5th, cuttings, including eight to twelve inches of the top of four tomato plants, were connected with the hydrant as follows: A cork, bored to receive glass tubing sufficient to give four delivery tubes, was inserted in a rubber hose and connected with the hydrant. The cork was then covered with resin and beeswax to prevent leakage. Small rubber tubing was then used to connect the delivery tubes with the tomato cuttings which were supported by being tied to stakes. In turning on the water it was found that the union at the cork was not water tight and it was necessary to leave the experiment until the morning of the 6th.

By this time the cuttings were badly wilted so that they drooped, and the edges of the leaves on one plant were dry. More of the resin and beeswax was brushed over the cork, melted paraffine was run over this and finally it was wrapped with a strip of cloth saturated with melted paraffine which made the union practically water tight. It was also found necessary to wire the rubber tubing to the end of the cuttings to prevent them from being thrown out by the force of the water pressure.

In turning on the water the pressure was so great it was necessary to wrap the larger rubber tube to prevent its bursting. In a few hours, the plants, though they had drooped and wilted so badly, were turgid and upright, only a few leaves of one plant which had dried at the edges not fully opening. On the 7th and 8th, during the middle of the day, transpiration being greater, the leaves were somewhat flabby though later in the day and during the night they were turgid.* By the 8th two large cushions of turgescient tissue had formed on one of the cuttings of the No. 18 variety, one on the stem about $2\frac{1}{2}$ cm long and extending about one-fourth the distance around the stem; the other one on the under side of a petiole about 3 cm long. At noon on the eighth the experiment was changed by placing a glass cage over the plants to lessen transpiration. The plants and the inside of the cage soon became so wet that water streamed slowly down.

*It was later found that iron rust accumulated slowly in the larger rubber tubes and partially clogged the vascular ducts, which accounted for the flabby condition during the middle of the day.

The cage remained on until the tenth. During this time the plants remained so wet no observations could be made on the development of the cushions.

During the preceding night the tissue of the No. 18 variety, being much more tender than the others, collapsed where the rubber tube was wired to the stem and permitted water to spurt through the delivery tube over the other plants. The cage was then removed at 8:45 A. M., and two plants were replaced with fresh ones, those being removed were the No. 18 variety and the plant the leaves of which had partially dried at the time the experiment was set up. Both of the fresh plants introduced were of the Lorillard variety. At the time of the mid-day observations on the 10th it was noted that the two other plants which had been connected four days, two days of the time under the moist cage, were drooped. They were left for another day with the hope that lessened transpiration during the night might revive them. On both of these plants, which were of the Lorillard variety, quite extended cushions were developed on the stem. On one plant were two cushions each about 3 *cm* long, on the other was one cushion 2½ *cm* long. The elevated, shining mass of cells could readily be seen so soon as they had dried after removal of the cage. December 11th these two plants were still drooped, probably not having revived during the night. They must have been near dissolution, for some of the leaves easily fell away from the stem. While there probably had been sufficient pressure on during the past 24 hours, the faucet was but a little way open and much iron rust had formed and clogged the vascular ducts at the point of union with the delivery tubes so that one of the fresh plants introduced the previous day had drooped. The three drooping plants were then replaced with fresh ones, one cutting being of the No. 18 variety and possessing quite a firm stem at the base. The water was turned on full pressure.† It was so great that within five minutes the fresh plants had been injected and water stood out in great drops at the ends of the veinlets on the edges of the leaves. This same phenomenon was observed in all the plants when freshly connected with the delivery tubes.

The exudation of drops from the edges of leaves through artificial injection of the plants has been observed by other experi-

†The pressure of the water was about 20 to 30 lbs.

menters, the water being forced into the cut end of the stem by the weight of a column of mercury*. Sachs also has produced the same effect in plants, by simply warming their roots, thus increasing root pressure.†

Some of the lower leaves had been cut from each of the last three plants connected with the tubes and from the cut surfaces a steady stream of water flowed slowly down the stem.

December 12th at 12:15 P. M., three of the plants were turgid while one was a little drooped. The epidermis of the stem and petioles of this one presented numerous longitudinal slits which perhaps offered opportunity for freer evaporation, and during mid-day when the air was comparatively dry and warm it became limp, while toward evening (4:30 P. M) it became turgid. In one of the turgid plants several of the leaves presented quite extensive areas where the intercellular spaces were injected so that these portions of the leaf exhibited a water-soaked appearance, and drops of water stood out upon the lower surface of such areas. In all of the plants a small amount was expelled from the axils of some of the leaves, collecting in drops which flowed away at intervals.

One of the delivery tubes broke during the night of December 12th, and on the morning of the 13th the water pressure was turned off. The tube was repaired at 9 A. M. The temperature was quite low in the house during the night of the 12th, owing to an accident in the boiler room. Probably for this reason, coupled with the fact that the plants were partly covered, little transpiration took place and the plants were quite turgid. On December 14th there were no points of interest to note.

During the night of December 14th one of the delivery tubes broke again and at the time on the morning of the 15th the pressure being off, the plants had all drooped. It was not deemed necessary to carry the experiment farther, but in order to photograph the experiment fresh plants were introduced and the photo-

* Moll, J. W. Ueber Tropfenausscheidung bei Blättern. Bot. Zeit., 1880, p. 49. Moll, J. W. Untersuchungen über Tropfenausscheidung und Injection bei Blättern, Verslagen en Mededeelingen d. k. Acad. van Wetenschappen, 2, R, xv. Deel. Amsterdam, 1880. See Just's Bot. Jahrb., 1880, i, p. 239. See also Bot. Zeitung, 1880, p. 49.

† Sach's Physiology, p. 278.

graph was taken ten minutes after the pressure had been turned on. The photograph is reproduced in Plate II to show the plan of the experiment and also the numerous drops which exuded from the leaves of the injected plants, and which can be seen running down on some of the stems.

The experience had during the trial has suggested that, should it ever be repeated, it would be well to place a filter in the large rubber hose in order to remove all particles of sediment, since considerable interference arises from the clogging of the vascular ducts of the cuttings.

It demonstrates, however, the relation which excessive root pressure* bears to the development of the cushions. Their

*It matters little for the present discussion of excessive turgidity whether "root-pressure" or the laws governing the lifting of water in the stems of plants is the real cause of the elevation of the water in the tomato plants beyond the point of root absorption. It is well known that root pressure cannot lift water to the height attained by some plants and that the transpiration current is not the only factor concerned, for it goes on sometimes independently of transpiration. See the following literature :

Jamin, Comptes Rendus, 1860, 1, pp. 172, 311, 385.

Unger, Sitzungsber. d. Akad. d. Wiss. z. Wien, lvii, 1, 1868.

Sachs, Vorlesungen über Pflanzen physiologie. Ueber die Porosität des Holze, cited by Ward. Timber and some of its diseases, 1889.

Boehm. De la cause du mouvement de l'eau Ann. d. Sci. Nat. 6th ser., T, xii, 1881.

Elfving, Ueber die, Wasserleitung im Holz. Bot. Zeit. 1882, Oct.

Hartig, Ueber die Vertheilung der organischen Substanz, des Wassers und Luftraumes in den Bäumen. Unters. a. d. Forst. Bot. Inst. München, 1882. Ueber die Ursache der Wasserbewegung in Transpirirenden Pflanzen. Ibid, 1883.

Dufour, Ueber den Transpirationsstrom in Holz-pflanzen, Arb. d. Bot. Inst. Würzburg, 1883.

Hartig, Die Gasdrucktheorie und die Sachs' che Imbibitionstheorie, Berlin, 1883. Cited by Ward, l. c.

Zimmerman, Zur kritik der Böhm-Hartigschen Theorie der Wasserbewegung in der Pflanze, Ber. d. Deutsch. Bot. Gessellsch. Bd. i, p. 183. Ueber die Jamin'sche Kette, Ibid. p. 384.

Westermaier, Zur Kenntniss der osmotischen Leistungen des lebenden Parenchym's. Ber. d. Deut. Bot. Gessellsch. Bd. i, 1883, p. 371.

Elfving, Ueber den Transpirationsstrom in den Pflanzen, Acta Societatis Scientiarum Fennicae, T, xiv, 1884, cited by Ward, l. c.

Scheit, Die Wasserbewegung im Holze, Bot. Zeit, 1884, p. 177.

Godlewski, Zur Theorie der Wasserbewegung in den Pflanzen, Pringsheims Jahrb. für wissensch. Bot. Bd. xv. Heft 4, 1884, p. 569.

appearance on the stem of the No. 18 variety through the agency of artificial pressure may not seem so convincing perhaps, since this variety was very susceptible to the trouble, and it was quite difficult to obtain a cutting for the experiment which was free from it.

Their appearance on the stems of the Lorillard variety, the stems of which are much more resistant to the trouble, is quite convincing that the lack of a proper equilibrium between root pressure and transpiration is an important factor in the cause.

To be certain that the anatomical characters of the cushions developed artificially comported with those developed under the prevailing conditions in the forcing house, portions of the stems of the No. 18 and Lorillard varieties used in the experiment, on which the cushions appeared, were hardened, sectioned and prepared for study by the same method used in the preparation of the former material. The plants having been kept under the moist cage so long, their surfaces were very wet and the superficial portions of the cushions were broken down.

Plate VII represents four sections from the preparations. The two upper figures, 13 and 14, are from the stem of the No. 18 variety, while the two lower figures, 15 and 16, are from the stem of a Lorillard. Each one of the figures includes the same depth structurally of the stem, the portion represented including the epidermis, layer of chlorophyll bearing cells, the collenchyma and cortical parenchyma. In each of the varieties the left hand figure in the Plate shows the anatomical structure of the cushion, while the right hand figure shows that of the opposite side of the stem where the tissue possesses its normal form, the drawing both of the left and right hand figures being made from

Kohl, Zur Wasserleitungsfrage, Bot. Zeit, 1885, p. 522.

Errera, Eun Transpiration Versuch. Ber. d. Deut. Bot. Gessellsch., 1886, p. 16.

Zimmerman, Zur Godlewskischen Theorie der Wasserbewegung in der Pflanzen Ber. d. Deut. Gessellsch, 1885, p. 290.

Hansen, Ein Beitrag zur Kenntniss des Transpirationsstromes, Arb. d. Bot. Inst. Würzburg, 1885, p. 305.

Scheit, Die Wasserbewegung im Holze. Jenaische Zeitschrift für Naturk, 1885. Cited by Ward, l. c.

Schwendener, Untersuchungen über das Saftsteigen, Sitzungsab. d. k. preuss. Akad. Wies, 1886. See Ward.

the same section. In both varieties the epidermis, the layer of chlorophyll bearing cells, and two layers of the cells of the collenchyma participate in the radial elongation. The remainder of the collenchyma and the cortical parenchyma shows a very turgid condition as compared with the same tissue on the opposite side of the stem as shown in the right hand figure. The structural features of these artificially induced cushions do not differ from those induced under the operation of the natural forces, and we are justified in concluding that this experiment forms additional cumulative evidence that the phenomenon is a result of the unequal operation of physiological processes concerned in plant growth.

Cultural experiment. In view of the large quantities of water absorbed by the roots in excess of the actual transpiration, a cultural experiment was suggested to be governed by such conditions as might be quite easily obtained in the soil of the bed where the plants grew which were most seriously affected. For this experiment twelve potted plants of the Lorillard variety were selected, because that variety seemed to be more resistant than the No. 18.

December 7th, they were placed on boards which rested on the soil of the bed at the south side of the tomato house where the plants of variety No. 18 were growing. They were allowed to remain in this condition for two days without any water, when the soil was quite dry and the leaves were limp. They were then divided into four lots of three each.

Those of lot No. 1 were removed from the pots and transplanted in the soil bed near affected plants at the east end of the bed, the soil having been stirred previously and allowed to become partially dry.

Those of lot No. 2 were allowed to remain in the pots on the boards.

Those of lot No. 3 were removed from the pots and transplanted in the soil of the bed by the side of affected plants at some distance from those of lot No. 1.

Those of lot No. 4 were transplanted to soil by the side of the walk where were other affected plants.

NOTE.—I wish to acknowledge here the generous assistance in carrying on these experiments rendered by Professor Bailey and Messrs. Corbett and Lodeman of the Horticultural Department.

Lots 1 and 2 were now given from day to day only sufficient water to keep them growing slowly, but not enough so that at any time the plants could become very turgid.

Lots 3 and 4 were supplied with sufficient water to keep the soil nearly saturated, enough so that the roots could absorb all the water possible at their highest activity, but not so much as to interfere with that activity. The plants of lots 3 and 4 were therefore kept very turgid by the large amount of water absorbed in comparison with that given off at the leaves, and in a few days the cushions of radially elongated cells began appearing on the under side of the leaf veins and mid-rib as well as on the under side of the petioles. In a few days more the curling of the leaves was perceptible, and in about ten days the leaves of nearly all the plants of these two lots were badly affected.

Those of lots 1 and 2 presented only a very few of the cushions on the leaf veins, and if the experiment had not been disturbed probably none would have appeared. During the period of about two weeks these plants were watered quite heavily twice by an attendant who had not been apprised of the nature of the experiment. Notwithstanding this, the difference in the plants resulting in the different degrees of irrigation was remarkable. The result of this experiment seems to be conclusive concerning the physiological nature of the disease.

Relation of tissue strength to the disease. An analysis of the laws of plant growth in connection with a study of the tissue strength and firmness of the tomato plants grown in the forcing house, as well as their environment, shows that the operation of these same forces which have produced this trouble has also produced a structural condition of the plant which renders it in the highest degree susceptible. One of the most striking things about the plants of the No. 18 variety is their rank growth and the succulent condition of the stems, petioles, veinlets and mesophyll of the leaves. They are remarkable for their frail and bulky nature. The young stems and petioles of a size up to 1 cm in diameter crush between the thumb and finger with very little pressure. In this variety the stems, petioles and veinlets are very subject to the disease. In the Lorillard variety the stems have been very little affected, the trouble occurring chiefly on the veinlets of the leaf. A comparison of the tissue strength of these

two varieties gives the key to their different tendencies in this respect. A stem or petiole of the Lorillard variety of the same stage of growth is in very strong contrast with those of the No. 18. Grasped between the thumb and finger there is a sense of great resistance to pressure, and when crushed the tissue appears fibrous and little watery compared with the soft, pulpy tissue of the No. 18.

A microscopic examination of young stems of the same stage of growth of these two varieties, presents the conditions upon which this difference in firmness of tissue depends. Plate VIII, figures 17 and 18, are from camera-lucida drawings of sections of stems from a No. 18 and Lorillard plant of the same stage of growth. In the Lorillard plant considerable woody tissue has already made its appearance as is shown in figure 18. The bast cells near the cortical parenchyma have also acquired their characteristic features. In the No. 18 plant, figure 17, at the same stage of growth there are as yet no cells presenting the characteristics of woody or bast cells. The presence of the woody cells themselves probably does not exert any influence in checking the tendency on the part of the cells of the fundamental tissue to stretch under the influence of turgescence. But it indicates a slower rate of tissue growth and firmer and, therefore, more resistant cell walls in the fundamental tissue.

There is, perhaps, some inherited disposition on the part of different varieties to this trouble. The history of the No. 18 strengthens this view. The original plant was remarkable for its rank growth, abundant foliage, and wide reach of limb, so that it was trained to lateral supports similar to some methods of grape training.

But there are also individual variations in the firmness or succulent, pulpy, nature of the stems, dependent upon varying conditions of growth and environment. This is a matter of common observation in all plants. The individual variations in the succulency or firmness of the tissues of the tomato plant render them more or less susceptible to the trouble.

Relation of growth to the development of the cushions. The relation of the actively growing parts of the plant to these oedematous portions also lends support to the view that they are the result of excessive turgescence. Turgescence is one of the first conditions

of growth and, other things being equal, rapidity of growth and the proportions of the growing shoot bear a close relationship to the degree of turgescence. The greater the degree of turgescence the larger will be the cells and the thinner their walls. Where the growing shoot or leaf meets with no obstruction to growth, the multiplication of cells and their enlargement and disposition into the various tissue elements accommodates all the water which by root pressure is distributed to them. The rate of growth is sufficient to relieve the great pressure though transpiration may be below the normal rate. Transpiration takes place more rapidly in young leaves* and shoots, but I do not think the difference in the susceptibility of very young and somewhat older tissues bears any very great relation to their different capacities for transpiration as will be shown below.

In the plants which have been most susceptible to the trouble it has been very noticeable that the growing shoot for four to six inches was entirely free from the cushions, while below this rapidly growing region the turgescence effected the abnormal stretching of groups of cells. The rate of growth at this point having declined, the excessive turgescence could no longer be relieved. In making a section of a stem at this point before the radial elongation of the superficial layers of cells began, it would be possible to tell on which side of the stem, or at what points on the circumference, the cushion would be developed. All of the cells in such succulent, rapidly developed stems are proportionately large and thin walled. But the force of the excessive turgescence has produced unequal results in the size of the cells at various points in the cortical parenchyma and the adjacent collenchyma and epidermis, so that the section shows much larger cells with consequently thinner walls at one or more points outside the cambium ring.

Not only do these cells contain more water but their cell walls are less resistant. It is at these points the radial elongation of the cells takes place, as can be seen by a comparison of numerous sections of affected stems.

In farther confirmation of this fact, that active growth relieves the tension and prevents the trouble temporarily, is the following observation made on the plants of the No. 18 variety which grew

*Sachs' Physiology of plants.

on the south bench at a point where the glass was about four feet above the soil. Before the growing ends of the plants reached the glass, the terminal portion, of five or six inches, was entirely free and the plants were in all respects similar to those of the same variety grown elsewhere, though perhaps not quite so rank and succulent. When the tops reached the glass their cramped condition, the greater humidity and other contingent circumstances prevented growth or reduced it to a minimum. Turgescence, however, continued, and in a few days nearly the entire surface of the terminal portion of the plants showed the development of these cushions. The trouble extended to the very end at the base of the leaf bud, and the very young and intermediate leaves were also affected, while plants of the same variety in other parts of the house, where there was still freedom for growth of the shoots and leaves, were no different from their former condition.

Similar developments in other plants. Reference has been made to probably a similar outgrowth produced on potato stems by placing rapidly growing potted potato plants under a bell jar.*

Sorauer† also describes a similar disease on *Ribes aureum*. In this case, the outer tissues being quite firm, the radial elongation frequently takes place in the deeper lying thin walled cells. In the preparation of the plants for forcing the lateral shoots are cut off. In the spring, when placed under conditions of forced culture in the plant houses, there being few buds where growth can take place and thus relieve the stem of the great amount of water absorbed by the roots; localised centers display abnormal turgescence through the radial stretching of the cell walls.

In 1879 experiments were conducted under the direction of Sorauer, in the forcing houses at Pankow near Berlin, with well rooted stems placed under conditions favoring forced growth. The results were quite positive, excellent examples of the trouble being thus produced.

*Ward, on some relations between host and parasite, etc. *Proceed. Roy. Soc.*, Vol. 47, 1890-1891, p. 393-443.

†Wassersucht bei *Ribes aureum*, *Freihoffs' Deutsche Gärtnerzeitung*, Aug., 1880. See *Justs Bot. Jahresb*, 1880. II Abth. p. 656-657.

Sorauer, *Pflanzenkrankheiten*, Zweite Auflage, Bd. I, p. 235-238.

Göschke, *Die Wassersucht der Ribes*, *Monatsschrift d. Verein z. Beförd. d. Gartenbaues in den kgl. Preuss. Staaten*, Octoberheft, 1880, s. 451. See *Just's Bot. Jahresb*, 1880, II Abth., p. 657.

He cites similar developments in the stems of young plum plants in water culture where the base of the stem was set too deep in the water. Also plants of *Phaseolus vulgaris* were subject to the trouble, when cultivated in wet sand if the seedling was too deep in the soil.

Masters,* at a meeting of the Royal Horticultural Society in 1878, showed leaves of potatoes, the under surface of which was marked with warts similar to those which occur on vine leaves when grown in too close and moist an atmosphere. The conditions under which the potatoes were grown were such as to produce the growths in question.

In 1889, vine leaves were exhibited at a meeting of the same society, which possessed similar warts on the under surface. The vines were grown under glass. Ward, to whom the matter was submitted, said it was due to poor ventilation of the house whereby the humid atmosphere favored abnormal turgescence which resulted in these outgrowths.†

Quabius‡ reports the trouble on pears grown out doors, which is the same as that in *Ribes aureum*.

Conclusion. Root pressure varies greatly in different plants. It would be interesting to know if there was any variation existing in the root pressure of different varieties of tomato plants grown under the same conditions, and if there was any correlation between the unit of pressure and the susceptibility of the variety to the œdema. Or, if root pressure is constant in the different varieties, does any variation exist in the power of the stem to lift the water which the roots absorb?

The study thus far made and presented in this report is in the nature of a contribution toward a solution of the at present obscure and unequal operation of the natural forces which are associated in the etiology of this most interesting phenomenon in abnormal plant development. To fully carry out this would lead the present writer too far afield at this time upon an enquiry into the operation of the laws of plant growth under artificial conditions of environment. The subject is none the less one of

*Gardener's Chronicle, 1878, I, p. 802.

†Gardener's Chronicle, 1889, I, p. 503.

‡Wassersucht bei Birnen. Jahresb. d. Schles. Centralverein's für Gärtner und Gartenfreunde zu Breslau, 1881. See Just's Bot. Jahresb, 1872, ii, p. 704.

great importance both from a scientific and economic standpoint, and deserves serious consideration. A student of cryptogamic botany, and especially one who devotes any serious attention to the relation existing between mycology and plant pathology cannot escape an enquiry into the pathological changes induced by the action of a symbiotic organism,* or whether the symbiont merely takes advantage of a low vitality or degenerate tissues introduced through unfavorable surrounding conditions, or the unequal operation of physiological laws. So much has been demanded of the writer by the present case and until the investigation had been carried to the extent presented here, it could not be said whether or not any symbiont stood in causal relation to the trouble.

To properly conduct the enquiry farther would necessitate a broad treatment of the manifold related forces. Compartments should be arranged so that the temperature of the soil and air could be controlled independently. Several such compartments should be arranged to maintain the soil at a given temperature and vary the air temperature. Several others with a given air temperature and varying soil temperature; variations also in the humidity of the air and moisture of the soil, the latter as has been shown can be treated to control the trouble. Studies with different kinds of soils would undoubtedly yield interesting and important results, for clay soil as is well known is more retentive of moisture and would less readily yield its moisture to the roots. Means for the artificial agitation and interchange of the air should be provided. The enquiry should embrace studies of nutrition and assimilation. The effect of artificial light should be studied in connection with the trouble. Although some of the earlier experiments, with the use of artificial light cast doubt† upon the question of carbon assimilation under such conditions it has

* Symbiont here is used in the broadest sense of that term, which means a common life for a greater or less period between two organisms.

† DeCandolle, *Memoires des savans étrangers de l' Institut des Sciences*, T. I, 1806, p. 333.

Physiologie végétale, 1832, T. I, p. 131.

Biot. *Froriep's Notizen* xiii, 10, 1840.

Hervé Mangon, *Production de la matière verte des feuilles sous l' influence de la lumière électrique*. *Compt. Rend, herb. d. Sci. Paris*, 1861, T. liii, p. 243.

recently been abundantly shown that carbon assimilation takes place* and in such amounts as in some cases to be a profitable use of such means of lighting.

Finally, the question of the origination of varieties, especially

*Famintzin, Die Wirkung des Kerasin—Lamp lichtetes auf *Spirogyra orthospora* Næg, Bulletin d. l' Acad. Imp. d. Sc. d. St. Petersburg, T. 10, Column 4-14, 1865, also T. 12, col. 97-108.

Prillieux, De l' influence de lumière artificielle sur la reduction de l' acide carbonique par les plantes. Compt. Rend, d. Sci. Paris, 1869, 2d Sem., pp. 408-412.

Heinrich, Versuchs-Stationen, 1871, xiii, p. 153.

Famintzin, Die Zerlegung der Kohlensäure durch Pflanzen bei künstlichen Beleuchtung. Bull. d. l' Acad. d. sci. d. St. Petersburg, T. 20, pp. 136-142, 1880.

Die Wirkung der Intensität des Lichtes auf die Kohlensäurererzetzung durch Pflanzen Ibid. pp. 296-314.

Déherain et Maquenne, Sur la décomposition d l' acide carbonique par les feuilles éclairées par lumière artificielles. Ann. Agronomiques, T, v, 1880, pp. 401-416.

Famintzin, La décomposition de l' acide carbonique par les plantes exposées à la lumière artificielles. Ann. d. Sci. Nat. Bot, 1880, T. 10, pp. 62-66.

Siemens, On the influence of electric light on vegetation and on certain principles involved. Proceed. Roy. Soc. 1880, vol. 30, pp. 210-219. Some farther observations on the influence of electric light on vegetation. Same vol., pp. 293-295. Recent applications of the dynamo—electric current to Horticulture, etc. Editorial in Nature Vol. xxii, 1880, p. 135.

Ricasoli-Firidolfi, L'. Orticulturs elettrica, Bull. della R. Soc. Tosc. d' Orticult, V. 8, Firenze, 1880. Cited in Just's Bot. Jahresb, 1880, 1, p. 315.

Siemens, Ueber den Einfluss des Elektrischen Lichtes auf die Pflanzen, Forschungen auf dem Gebiete der Agriculturphysik Bd, 5, S. 486. See Just's Bot. Jahresb., 1882, i, p. 43.

Wittrock, Om elektriska ljusets inflytande på växterna, Svenska Trädgårds förenings Tidskrift, 1882. Refers to Siemen's researches upon continuous electric lighting and compares the results with the long known facts concerning the effect of continuous sunshine in the arctic region which hastens development, and produces beautiful and pure colors in flowers, and promotes the formation of fruits rich in aroma, and hardy seeds. See Just's Bot. Jahresb. 1873, p. 564.

Bronold, Ueber Elektrische Pflanzenculturversuche Zeitschrift d. landw. Vereins in Bayern, 1884, Jahrg. 74, Heft. i, p. 16-18. See Just's Bot. Jahreb. 1884, i, p. 6.

Bailey, Some preliminary studies of the Influence of the Electric Arc Lamp upon Greenhouse Plants, Bulletin 30. Cornell University Agr. Exp. Station, Aug. 1891.

suitable to forcing-house culture should be taken up, keeping in view the desirability of the proportionate and harmonious evolution of correlated structures and functions.

GEO. F. ATKINSON.

DESCRIPTION OF PLATES.

Plate I. Photographs showing œdematous cushions on stem and leaves of tomato.

Plate II. Photograph showing detail of connection of tomato cuttings with the hydrant, and drops of water hanging from edges of leaves which were forced through the veins by the water pressure.

Plate III. Anatomical structure of œdematous cushion on leaf vein, figure 4 healthy part of vein, figure 5 from center of cushion

Plate IV. Anatomical structure of œdematous cushion in mesophyll of leaf, near termination of leaf vein. Figure 6, appearance of small cushion magnified with pocket lens. Figure 7, section through edge of small mesophyll cushion. Figure 8, section through center of partially collapsed mesophyll cushion. Plate IV was made from specimens sent by L. R. Jones, of Burlington, Vermont.

Plate V. Structure of young œdematous cushion in young stem of No. 18 variety, showing also detail of tissue. In this and all the plates which follow, *med.* = portion of parenchyma from the pith or medulla; *w* = woody cells; *ca* = cambium zone; *b* = bast; *c p.* = cortical parenchyma; *co* = collenchyma; *ch* = chlorophyll layer of cells; *ep* = epidermis.

Plate VI. Figure 11, from center of young œdematous cushion in young stem of No. 18 variety, taken from same series as figures 9 and 10 of Plate V. Figure 12, from center of older cushion on older part of stem of No. 18 variety.

Plate VII. Comparative study of œdematous cushions produced artificially, with the normal tissue on opposite side of stem. Figures 13 and 14, from No. 18 variety; figures 15 and 16, from Lorillard variety.

Plate VIII. Comparative study of tissue firmness of No. 18 variety (figure 17) with Lorillard variety (figure 18) at same stage of growth.

SUMMARY FOR PRACTICAL PURPOSES.

The œdema of the tomato is a swelling of certain parts of the plant brought about by an excess of water which stretches the cell walls, making them very thin and the cells very large. The excess of water may be so great that the cell walls break down, and that part of the plant dying, exerts an injurious influence in adjacent parts.

The excess of water in the tissues is favored by the following conditions :

1. *Insufficient light.* The long nights of the early winter months, numerous cloudy days, and in part, the walls and framing of the forcing house deprive the plants of needed light. By a process known as *transpiration*, plants are relieved of much water when well lighted, but in poor light, since the roots are absorbing water, it is apt to accumulate to excess. Well lighted parts of the house then should be selected for the tomatoes.

2. *Too much water in the soil.* Water in excess can be withheld from the soil and prevent the trouble, and yet provide enough for the plants to grow.

3. *The temperature of the soil may be too near that of the air.* A high temperature of the soil makes the roots active, and if the temperature of the air is not considerably higher an excess of water is apt to accumulate in the plant. The aim would be then to have the temperature of the air considerably higher than that of the roots.

Lack of proper light also brings about the following harmful conditions :

1. *Acids in the plant accumulate in the dark and in strong light they decrease.* When there is an abundance of water in the plant these acids draw large quantities into the cells, causing the cells to swell, resulting many times in œdema, or in the killing of the protoplasm so that these parts of the plant die and become brown or black.

2. *Lack of light causes weak cell walls.* It is only when well lighted that plants are capable of making substances to build up cell walls with. Therefore, lack of light not only favors the accumulation of water, if other things are favorable, but it prevents the plants from building up strong tissues. In such cases plants

can *grow themselves to death*. Possibly artificial light might be used to advantage.

A quiet and close atmosphere also favors the accumulation of water in the plant. Good ventilation should then be secured. Some means for the artificial agitation or exchange of the air at night might probably be profitably devised.

Varieties of tomatos more subject to the œdema. Those with a tendency to a very rapid and succulent growth are more liable to the trouble. Tomatos which develop a firm woody young stem are less liable to it.

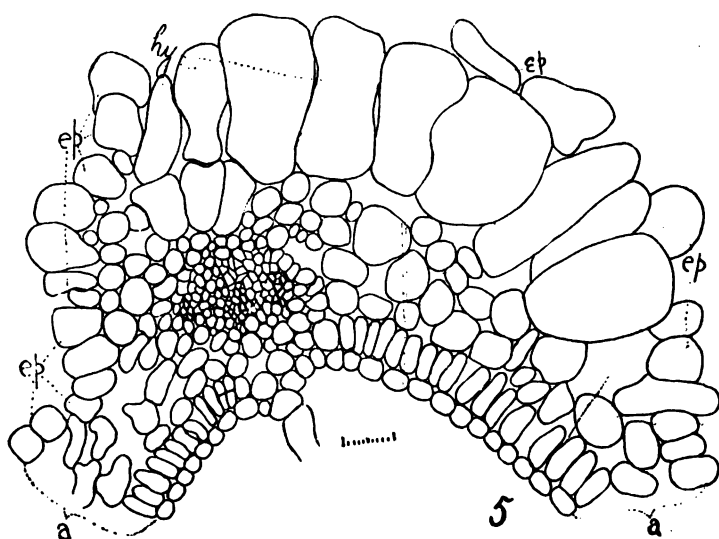
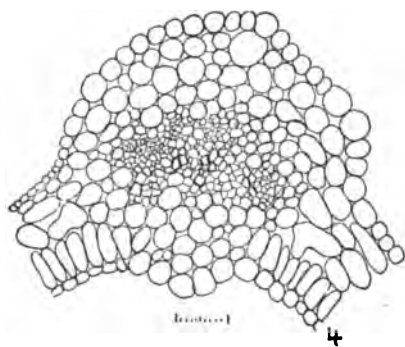
GEO. F. ATKINSON.



PLATE I. *Œdema of the Tomato.*

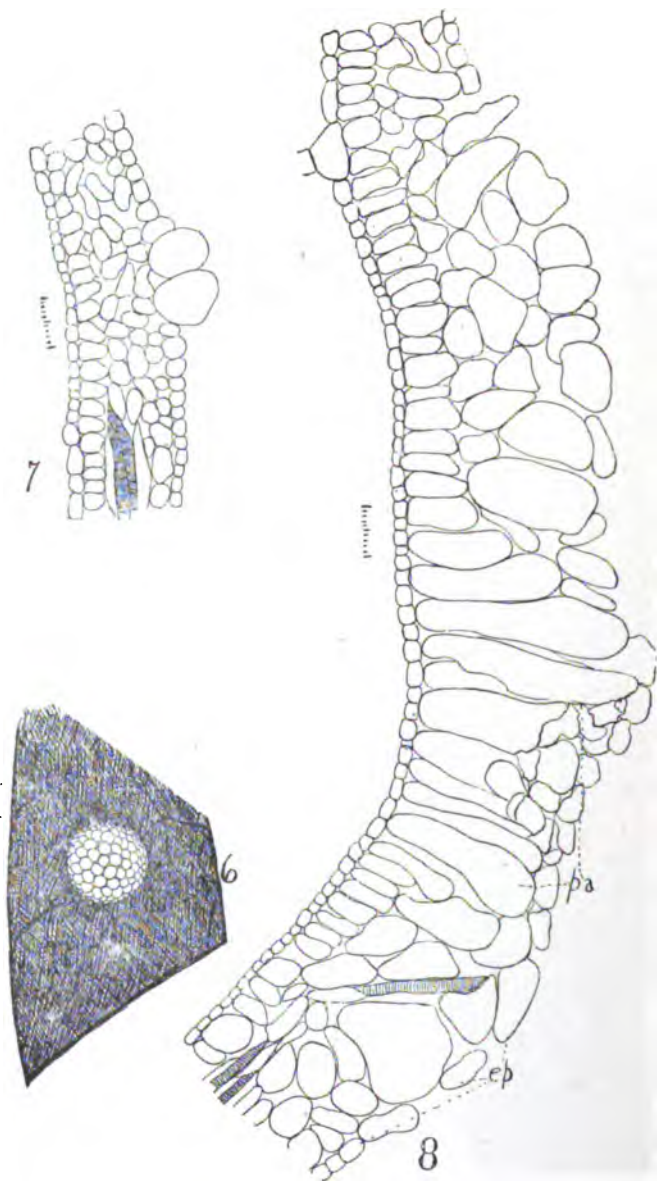


PLATE II. *Photograph of experiment for injection of cuttings with water.*



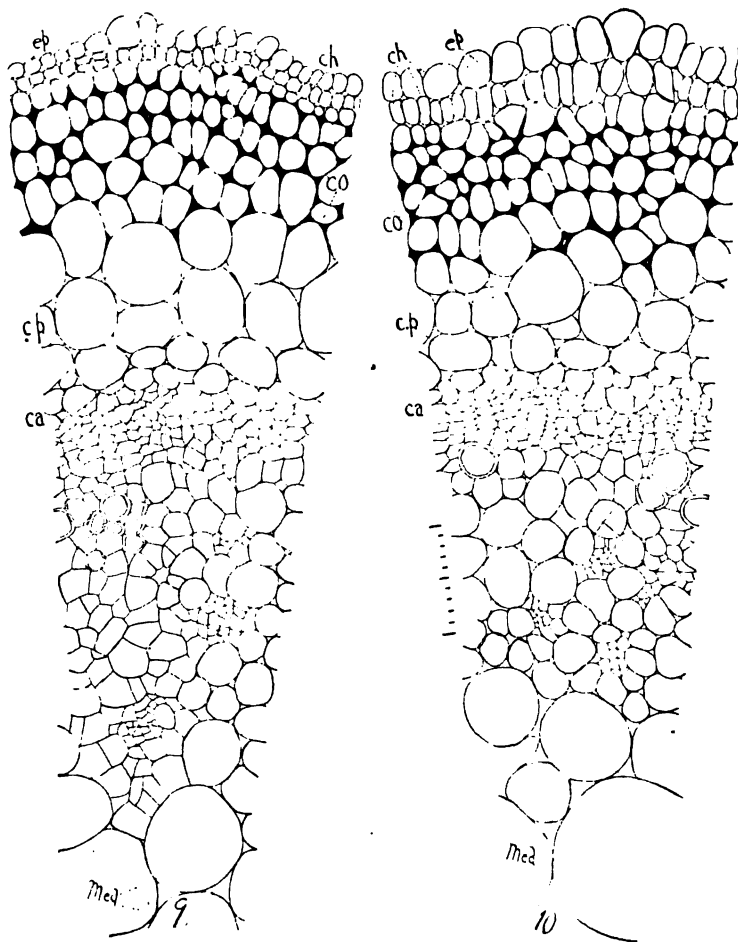
G. F. Atkinson, del.

PLATE III. *Edema of the Tomato.*



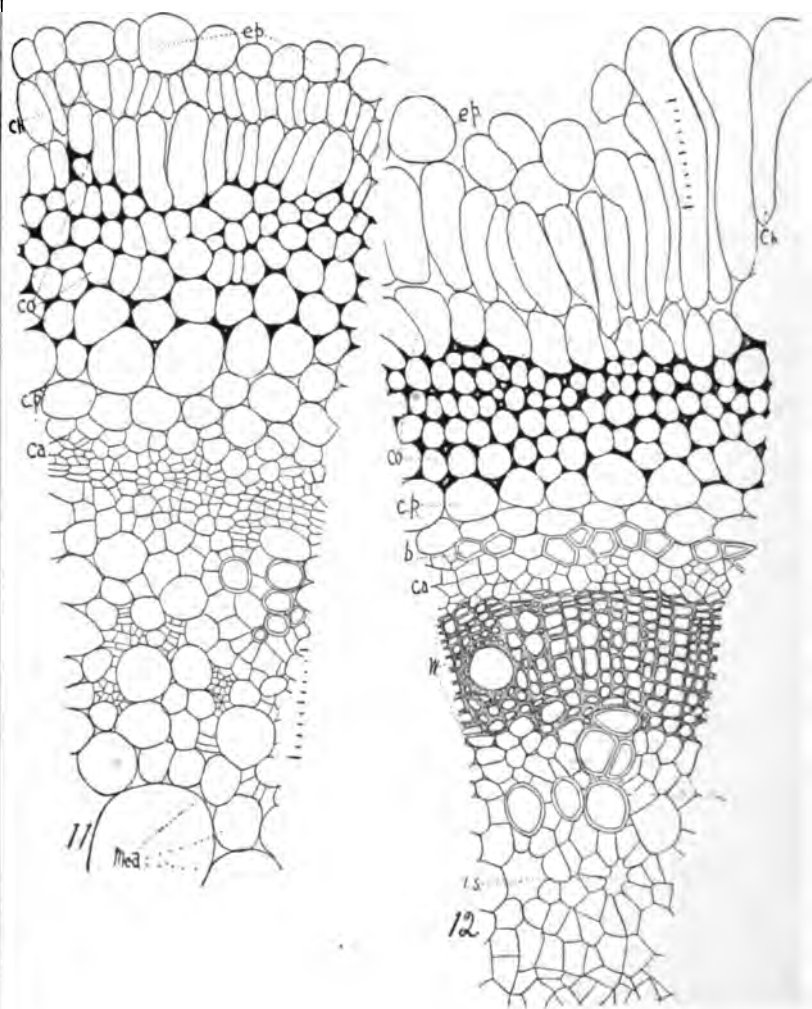
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PLATE IV. *Edema of the Tomato.*



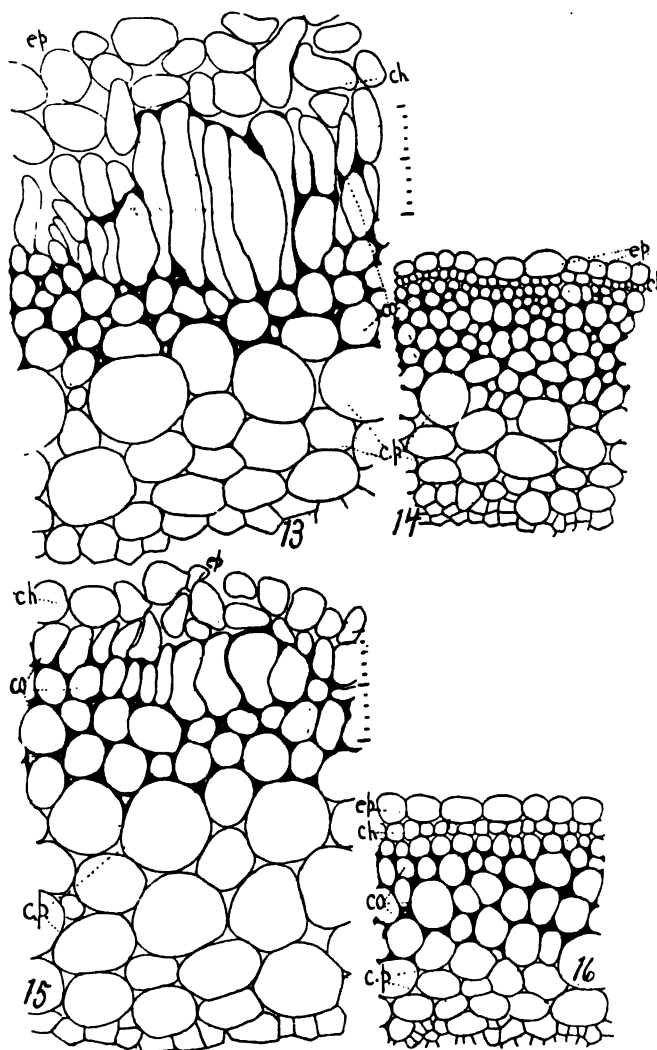
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PLATE V. *Edema of the Tomato.*



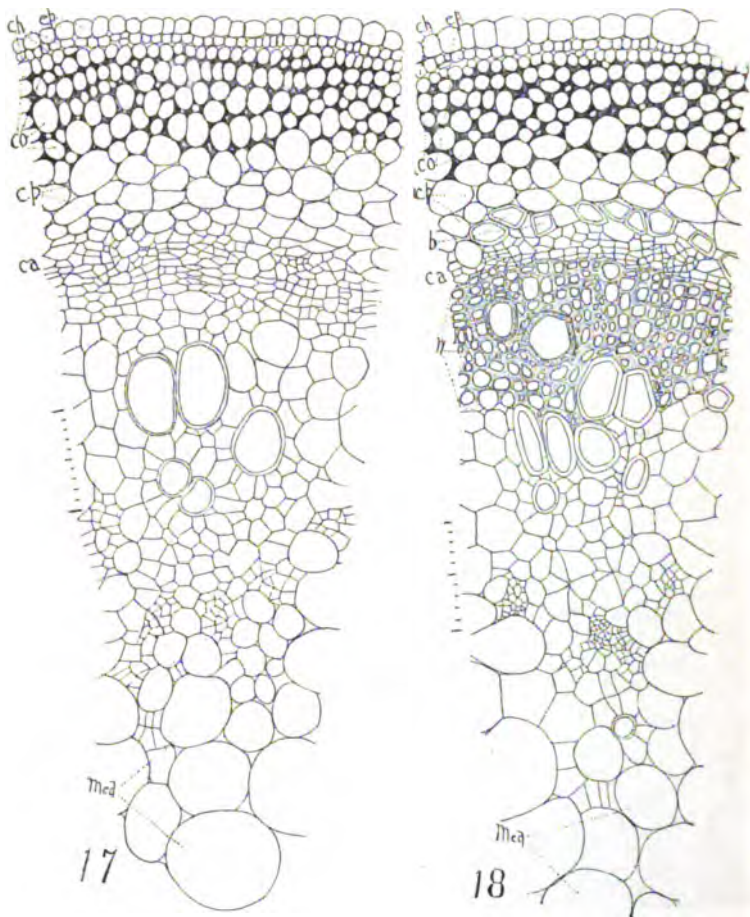
G. F. Atkinson, del.

PLATE VI. *Edema of the Tomato.*



G. F. Atkinson, del.

PLATE VII. *Edema of the Tomato.*



G. F. Atkinson, del.

PLATE VIII. *Edema of the Tomato.*

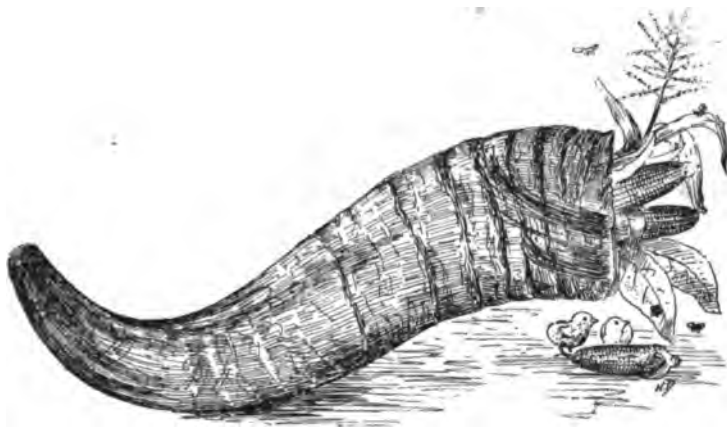
Bulletin 54.

June, 1893.

Cornell University Agricultural Experiment Station.

AGRICULTURAL DIVISION.

DEHORNING.



By I. P. ROBERTS.

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1893.

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BULLETINS OF 1893.

50. The Bud Moth.
51. Four New Types of Fruits.
52. Cost of Milk Production.—Variation in Individual Cows.
53. Œdema of the Tomato.
54. Dehorning.

THE LEGALITY OF DEHORNING.

The practice of removing the horns from cattle was first publicly advocated by H. H. Haaf of Illinois about 1885 or 1886, and since that time has come to be extensively practiced in all parts of the country: It has been found to be of great practical utility in rendering animals more docile and quiet, in rendering them much less capable of injuring each other or mankind, and in reducing the space necessary for safe housing and shipping. The operation though somewhat severe, has been found to be a very safe one, usually leading to little or no functional derangement and not followed by severe pain or profuse hemorrhage. Nevertheless it has seemed to many that to deprive an animal of its horns was to practice upon it an unwarrantable cruelty, and numerous prosecutions, therefore, have taken place under the law for the prevention of cruelty to animals. Several such prosecutions have recently taken place in this State and as numerous inquiries in relation to the general subject have been received at this station, it has seemed well to give a brief summary of the present status of the matter.

The New York law, covering cases of cruelty to animals, is found in Sections 655 and 669 of the Penal Code, and is as follows:

THE NEW YORK LAW CONCERNING CRUELTY TO ANIMALS.

Sec. 665. Overdriving Animal; Failing to Provide Proper Sustenance.—A person who overdrives, overloads, tortures or cruelly beats or unjustifiably injures, maims, mutilates, or kills any animal, whether wild or tame, and whether belonging to himself or another, or deprives any animal of necessary sustenance, food or drink, or neglects or refuses to furnish it such sustenance or drink, or causes, procures or permits any animal to be overdriven, overloaded, tortured, cruelly beaten or unjustifiably injured, maimed, mutilated or killed, or to be deprived of necessary food or drink, or who willfully sets on foot, instigates, engages in, or in any way furthers any act of cruelty to any animal, or

any act tending to produce such cruelty, is guilty of a misdemeanor.

SEC. 669. DEFINITIONS. 1. The word "animal," as used in this title, does not include the human race, but includes every other living creature.

2. The words "torture" or "cruelty" includes every act, omission, or neglect, whereby unjustifiable physical pain, suffering or death is caused or permitted.

RECENT CASES UNDER THE LAW.

On April 13th, 1893, upon complaint of an agent of the American Society for the Prevention of Cruelty to Animals, Mr. O. H. Smith, of Ellicottville, N. Y., president of the Farmers' Association of Cattaraugus County, was arrested, charged with cruelty to animals in having dehorned his herd of cows in the autumn of 1891. Mr. Smith was taken before a Justice of the Peace, Mr. John Ward, of Ellicottville, and gave bonds to appear for trial on April 26th, but before the trial was joined, upon the affidavit of Mr. Smith's counsel, Hon. Wm. G. Laidlaw, County Judge Vreeland granted an order removing the case from the Justice's Court and carrying it to the Grand Jury of the county. On May 16th, the matter came up before the Grand Jury. A number of witnesses, on behalf of both Mr. Smith and the Society for the Prevention of Cruelty to animals were examined, but the Grand Jury failed to find sufficient evidence of cruelty and refused to indict Mr. Smith.

A second case is that of Mr. J. N. Middaugh of Friendship, Allegany Co.; his case was entirely similar to that of Mr. Smith's, except that he had dehorned a much larger number of cattle. The history of the case is about as follows:

J. N. Middaugh is a veterinary surgeon, residing at Friendship, Allegany Co., N. Y. During the past winter he dehorned over two thousand head of cattle with entire success in different parts of the county. About April 29th he was arrested on a warrant sworn out by an agent for the American Society for the Prevention of Cruelty to Animals, and taken before Justice Torrey of Wellsville. On motion of Middaugh's attorneys, Church & Church, the case was removed from trial before the Justice, and Judge Norton made an order to refer the matter to the Grand Jury

and the bail of the accused was fixed at \$200. On May 23, the complainant appeared before the Grand Jury with two veterinary surgeons from Philadelphia. Each testified as to the anatomy of the horn and of the probable degree of pain caused the animal by the operation of dehorning. Each also testified that he had never seen the operation performed or had observed its effect upon animals, or observed the action of animals particularly before and after the operation. The Grand Jury, prompted by a desire to go to the bottom of the matter, subpoenaed about thirty of the representative farmers of the county who were large cattle breeders and who had observed extensively the effect of dehorning upon their own and other cattle. Without exception these witnesses testified that they believed dehorning to be highly beneficial and in the interest of humanity. Several of the Grand Jurors had themselves had experience with dehorning and these, including the foreman, were excused from all consideration of the matter and excluded from the jury room during the entire examination that no claim could be made but that the case was fairly considered. After all testimony had been put in, the ballot was taken and not a single vote was given for the indictment.

It will thus be seen that the Grand Juries of two counties of the State, after full and careful testimony, have decided, by refusing indictments, that the removing of the horns from an animal does not constitute "cruelty" under the statute.

PROSECUTIONS IN OTHER STATES.

As has already been said, H. H. Haaf of Illinois was one of the first to publicly advocate and largely practice dehorning. He was likewise one of the first to be prosecuted therefor. On complaint of the Illinois Humane Society, Haaf was arrested for practicing cruelty to animals in having removed the horns from a certain heifer. He was tried before Justice Steele at Geneseo, Ill., on January 22d, 1886. A large number of witnesses were examined on both sides and a verdict of acquittal was rendered Mr. Haaf.

At least two prosecutions have taken place in Pennsylvania, one in 1886, in which the Pennsylvania Society for the Prevention of Cruelty to Animals prosecuted a farmer named Hirst. The case was submitted to a jury, who dismissed the action but

imposed one-half of the costs on the defendant and one-half on the Society. The other in 1892, in which the Western Pennsylvania Humane Society brought an action against a farmer near Pittsburgh. A large number of witnesses were examined and a verdict of acquittal was brought in by the Jury.

THE CASE IN CANADA.

By far the most thorough examination of the legal aspects of dehorning in its relation to cruelty to animals has been made in Canada and published in 1892 in the Report of the Ontario Commission on the Dehorning of Cattle. From this report we quote as below :

Origin of the Practice in Ontario.

The practice of dehorning cattle appears from the evidence to have been first introduced into this Province in the year 1888, by Messrs. Kinney and Johnson, farmers, of South Norwich, Oxford county. It was not, however, adopted to any great extent until February, 1890, when Mr. Chauncey Smith, a farmer's son residing in the township of Dereham, Oxford county, on returning from a visit to the State of Illinois, where the practice prevailed, set an example by dehorning his father's herd. In a short time this example was followed by Mr. Smith's neighbors, many of whom became warm advocates of the practice.

Considerable controversy arose as to the amount of pain involved in the operation, and in February, 1891, Mr. W. V. Nigh, a farmer of Avon, Middlesex county, was prosecuted before two Justices of the Peace at London on the charge of cruelty. The case was dismissed on the evidence of ten witnesses that the operation was a beneficial one and the suffering of short duration.

The practice continued to extend, and the services of Messrs. Chauncey Smith and W. A. Elliott, who had made a study of the operation, were frequently in demand. Mr. Smith stated in evidence that he had dehorned 250 head, while Mr. Elliott gave the number of cattle he had operated upon to be about 400. The great majority of these operations took place in Oxford, Norfolk and Elgin counties, and although dehorning has been tried exper-

imentally in various parts of the Province, the practice is largely confined at present to the counties mentioned.

Acting on behalf of the opponents of the practice, Mr. Charles Hutchinson, Crown Attorney of Middlesex,* instituted proceedings in January, 1892, against Messrs. William York, Sr., W. A. Elliott and Edward York, charging them with cruelty to animals in having cut off the horns of the cattle of the first named defendant. The case was called at the Interim Sessions, London, on January 6th, before Messrs. Smythe and Lacey, Justices of the Peace for the County of Middlesex, and after a thorough trial each of the defendants was fined \$50 and in default of payment one month in the County Jail.

The proceedings at the trial were given a widespread publicity and an animated newspaper controversy was carried on for several weeks. The greatest difference of opinion was noticeable, the advocates of the practice claiming that it was a positive kindness to the animals, in addition to being a commercial advantage, while many who were opposed to it regarded the operation as one of excruciating torture.

In view of these circumstances, a Commission was issued on March 9, 1892, by the Ontario Government to Hon. Charles Drury of Crown Hill, Farmer; Richard Gibson of Delaware, Breeder; D. M. Macpherson, of Lancaster, Dairyman; Andrew Smith, of Toronto, Veterinarian; Henry Glendinning, of Manilla, Farmer; and J. J. Kelso, of Toronto, Journalist, authorizing and requiring them "To obtain the fullest information in reference to the practice recently introduced into this Province of dehorning cattle, and to make full inquiry into and report with all reasonable speed the reasons for and against the practice, as well by the examination of witnesses as by collecting whatever is accessible of the evidence which has been given by experts or others in the trials which have taken place on the subject in England, Ireland

*The Dominion statute against cruelty to animals under which the prosecutions were brought, reads as follows: "Everyone who wantonly, cruelly, or unnecessarily beats binds, ill treats, abuses, overdrives or tortures any cattle, poultry, dog, domestic animal or bird shall, upon summary conviction before two justices of the peace, be liable to a penalty not exceeding \$50 or imprisonment for any term not exceeding three months."

and Scotland, and in this Province, the judgments in the cases tried and any other useful information from any quarter which may be in print or otherwise obtainable." Hon. Mr. Drury was named as chairman and Mr. Kelso as secretary.

Evidence before the Commission.

Evidence was received from the representatives of all the interests affected by the practice, including general farmers, dairymen, drovers, exporters, wholesale and retail butchers, cattle market attendants, tanners, hide merchants, veterinary surgeons, medical practitioners and members of Humane Societies,—ninety-eight in all.

Of the farmers examined, nearly seventy in number, all who had either performed or seen the operation performed, with three or four exceptions, were strongly in favor of it, the majority stating that they were prejudiced against it on the grounds of cruelty until they gained a practical knowledge of it. Of the farmers opposed to the practice not more than three or four had ever seen the operation but they thought it cruel and unnecessary.

Evidence as to the loss caused by animals using their horns upon each other was given by cattle buyers and others in frequent attendance at the cattle market, and also by butchers and tanners.

Among veterinary surgeons a considerable conflict of opinion was found to exist. As in the case of the farmers those who had seen the operation and observed its effects were in favor of it, while those who had not seen it were opposed to it.

Indeed, as regards all the evidence received by the Commission it might almost be given as the rule that where the operation was properly and skilfully performed those witnessing it, however prejudiced before, became converts to it, while the great bulk of the opposition came from parties not acquainted with the operation, and who entertained exaggerated ideas as to its severity.

In no case were witnesses able to refer to an instance where a farmer was dissatisfied with the results or willing to give up his right to continue the practice, after having performed the operation.

In addition to the evidence as to the amount of pain involved in the operation, much evidence was received as to the commer-

cial advantages accruing from the operation, and emphasizing the point that a great deal of suffering is prevented by the removal of the horns.

No fault could be found with the character and bearing of those who testified in favor of the practice. They were men who would readily be selected as representative of the best class of farmers, and even those opposed to them on this question willingly testified to their respectability and good standing in the community.

A great deal of opposition to the practice was met with from members of humane societies and others who believed that the operation was purely for commercial considerations and therefore unjustifiable, and that the pain inflicted was excessive. These witnesses were strengthened in their belief by the judgment of Lord Chief Justice Coleridge and Mr. Justice Hawkins,* a verbatim report of that adverse decision having been printed and distributed by the Royal Society for the Prevention of Cruelty to Animals.

Recommendations of the Commission.

The Commission would therefore recommend as follows:

1st. That the practice of dehorning be permitted where performed with reasonable skill, with proper appliances, and with due regard to the avoidance of unnecessary suffering, and that the Ontario Government should bring to the attention of the Dominion Government the desirability of amending the law relating to cruelty to animals, so as to give effect to this recommendation.

2d. That the Ontario Government should direct the management of the Ontario Experimental Farm to experiment with chemicals on the horns of young calves and also by cutting out the embryo horn, with a view to ascertaining whether these methods are more desirable than sawing off the horns when they have attained their full growth.

CHARLES DRURY, Chairman,
RICHARD GIBSON,
HENRY GLENDINNING,
D. M. McPHERSON,
ANDREW SMITH,
J. J. KELSO, Secretary.

*P. 118.

IN GREAT BRITAIN,

The practice of dehorning seems to have been in vogue considerably earlier than in this country and there are decisions in regard to its legality going back as early as 1884. The English law is similar to the ones in force in this state and in Canada and is as follows: "If any person shall cruelly beat, ill treat, over drive, abuse or torture, or cause or procure to be cruelly beaten, ill treated, over driven, abused or tortured any animal, such offender shall be subject to such punishment as is prescribed by that statute."

A summary of the British decisions is given below:

Summary of British Trials.

Ireland, 1884—Brady v. Mc Argyle. Magistrate refused to convict. Exchequer division held that conviction should have been entered. (Baron Dowse and Mr. Justice Andrews.)

Ireland, 1885—Callaghan and McEvoy v. the S. P. C. A. Three magistrates at the petty sessions held that they were bound to convict in accordance with the above decision. Common pleas division of the High Court of Justice overruled this, and held that the operation skillfully performed, did not come within the meaning of the Act. (Chief Justice Morris, Mr. Justice Harrison and Mr. Justice Murphy.)

Scotland, 1888—Penton v. Wilson. Acquitted by the sheriff-substitute. Case appealed to a higher court, and the sheriff-substitute sustained. (Lords Young, Mc Laren and Rutherford Clark.)

England, 1888—Ford v. Wiley. Acquitted by a board of five magistrates. Higher court held that conviction should have been entered. (Lord Chief Justice Coleridge and Mr. Justice Hawkins.)

Scotland, 1891—Penton v. Wilson. Appealed to a higher court, and the two previous decisions unanimously confirmed. (The Lord Justice Clark, Lords Mc Laren, Trayner, Wellwood and Kyllachy.)

Ireland, 1891—Newland v. Mc Donagh. Two magistrates refused to convict. Higher court sustained this decision. (The Lord Chief Justice, Mr. Justice O'Brien, Mr. Justice Johnson, Mr. Justice Holmes and Mr. Justice Gibson.)

SUMMARY.

In the United States, so far as we have been able to learn, all trials upon charges of cruelty to animals by dehorning have resulted in the acquittal of the accused parties.

In Canada at least two trials resulted in the acquittal of the accused, but in a third trial the conviction of the parties resulted in the appointment of a Government Commission which made a report strongly recommending the practice and urging the passage of the necessary legislation to give it effect.

In Great Britain there have been decisions on both sides. Those in Ireland and Scotland being in favor of the legality of the practice and those in England, notably that of Lord Chief Justice Coleridge and Mr. Justice Hawkins, against. Of twenty judges of higher courts who have passed upon the subject, sixteen declared the practice to be legal, while four pronounced it illegal.

ON PREVENTING THE GROWTH OF HORNS.

Ever since the practice of dehorning has come into favor it has seemed to many that if by some means the horns could be prevented from growing it would be for many reasons much preferable to removing the horns from full-grown animals. As several so-called "Chemical Dehorners" have been on the market for some time, it has seemed well to undertake some experiments with certain caustic reagents to ascertain, if possible, if any could be relied upon to prevent the growth of horns. Accordingly on November 5th, 1891, five calves were selected from the University herd for experimentation in preventing the growth of horns by the application of various chemical compounds. These chemicals were compounded and either applied by or under the direction of Prof. James Law, Professor of Veterinary Science.

One of these calves was a thoroughbred Jersey; one a thoroughbred Holstein, and the remaining three, high grade Holsteins.

The following table shows the age and breed of the calf and the chemicals used on each horn:

		Age in days.	
Calf No. 1...	Holstein.....	30	Right horn, caustic potash. Left horn, caustic potash.
Calf No. 2...	Holstein.....	34	Right horn, hydrochloric acid. Left horn, sulphuric acid mixed with sulphur.
Calf No. 3...	Jersey.....	64	Right horn, chloride of zinc. Left horn,, " " "
Calf No. 4...	Holstein.....	65	Right horn, sulphuric acid with glue and carbolic acid. Left horn, chloride of antimony.
Calf No. 5...	Holstein.....	45	Right horn, chromic acid ointment. Left horn, chromic acid solution.

The caustic potash applied to the horns of calf No. 1 was in the form of a paste and a liberal amount was applied to each horn. Only calves numbers 1 and 3 suffered from the application; these apparently suffered considerable pain soon after the application and this pain continued until the second day; after that time all calves appeared bright, active and without pain.

November 12th a careful examination of all the horns was made and the following conditions were noted:

Calf No. 1,—Right horn, growth apparently destroyed.
Left horn, " " "

Calf No. 2,—Right horn, not affected.
Left horn, growth apparently destroyed.

Calf No. 3,—Right horn, not affected.
Left horn, " "

Calf No. 4,—Right horn, not affected.
Left horn, " "

Calf No. 5,—Right horn, not affected.
Left horn, " "

The left horn of calf No. 4 was somewhat sensitive to the touch, but appeared to be perfectly healthy. As most of the horns treated were not affected by the reagents it was thought

best to give them another treatment and by so doing to try still other chemical reagents; accordingly the following chemicals were applied :

Calf No. 2,—Right horn, chloride of mercury and hydrochloric acid.

Calf No. 3,—Right horn, caustic potash.

Left horn, “ “

Calf No. 4,—Right horn, chloride of mercury and hydrochloric acid.

Left horn, “ “ “ “ sulphuric acid.

Calf No. 5,—Right horn, chloride of mercury and hydrochloric acid.

Left horn, “ “ “ “ sulphuric acid.

The caustic potash applied to calf No. 3 was not so concentrated nor so much applied as to calf No. 1 in the first trial.

An examination of all the calves Feb. 14, 1892, showed the conditions to be as follows :

Calf No. 1,—Both horns destroyed.

Calf No. 2,—Right horn not affected.

Left horn destroyed.

Calf No. 3,—Right horn not affected.

Left horn not affected.

Calf No. 4,—Right horn not affected.

Left horn destroyed.

Calf No. 5,—Right horn not affected.

Left horn not affected.

It will be seen that the second application destroyed the growth of only one horn, the left horn of calf No. 4, and from the action of the different reagents on the calves of different ages it seemed evident that chemicals, to be effective in preventing the growth of horns and not make serious sores, must be applied early in the life of the animal.

As caustic potash had proved the most effectual in these trials, it was used exclusively in succeeding experiments. Since the above experiments were made the growth of the horns on seven other calves have been successfully prevented by a single application of caustic potash to each horn, *but in no case was the appli-*

cation made when the calves were more than one month old. Illustrations 1, 2 and 3 show the appearances of the heads after treatment with the various chemical agents. These illustrations were reproduced from photographs taken in December, 1892.

Fig. 1 is the head of calf No. 1, growth of horns destroyed by caustic potash paste.



Fig. 1.

Fig. 2 is the head of calf No. 2; left horn destroyed by sulphuric acid mixed with sulphur.

Fig. 3 is the head of a calf with horns destroyed by stick caustic potash applied in small quantity to the embryo horn early in life.



Fig. 3.



Fig. 2.

The results of all the experiments made at this station lead us to believe that the use of caustic potash is by far the easiest, most humane and most certain method of securing hornless cattle. The best time to apply preventive reagents is early in the life of the animal, just as soon as the little horns can be distinguished by the touch. The manner of applying caustic potash* is as follows:

The hair should be closely clipped from the skin and the little horn moistened with water to which soap or a few drops of ammonia have been added to dissolve the oily secretion of the skin, so that the potash will more readily adhere to the surface of the horn. Care must be taken not to moisten the skin except on the horn where the potash is to be applied. One end of a stick of caustic potash is dipped in water, until it is slightly softened. It is then rubbed on the moistened surface of the little horn. This operation is repeated from five to eight times, until the surface of the horn becomes slightly sensitive. The whole operation need take only a few minutes and the calf is apparently insensible to it. A slight scab forms over the surface of the budding horn

* Caustic potash comes in the form of round sticks about the size of a lead pencil. It may be had at any drug store and should be kept from exposure to the air as it rapidly absorbs moisture.

and drops off in the course of a month or six weeks, leaving a perfectly smooth poll. No inflammation or suppuration has taken place in any of the trials we have made. The results of these experiments warrant the following recommendations:

1. That for efficiency, cheapness, and ease of application, stick caustic potash can be safely recommended for preventing the growth of horns.

2. The earlier the application is made in the life of the calf, the better.

PATENTED CHEMICAL DEHORNER.

On March 16, 1893, we received from the John March Co., 17 & 19 River St., Chicago, Ill., a circular concerning their "Method of Dehorning easily, safely, perfectly and cheaply with the John March Company's Chemical Dehorner." Accompanying the circular was a bottle of the "Dehorner" containing about a gill of clear liquid. The circular besides setting forth the merits of the liquid and quoting numerous testimonials, laid claim to a patent granted July 12th, 1892, "On method of preventing the growth of horns by applying any substance to the embryo horn to prevent its growth" and warning all against infringement.

The existence of such a patent with such sweeping claims was a great surprise to us, as various compounds intended to prevent the growth of horns had been largely advertised in the Agricultural press for several years, and caustic potash had been publicly recommended for the purpose at least as early as February, 1892.*

On looking the matter up it was found that patent No. 478,877 was issued July 12th, 1892, to John March, Assignor to the John March Company, on a Method of Suppressing Horns in Cattle, the important specifications of which are as follows:

"Be it known that I, JOHN MARCH, of White Oak Springs, in the county of Lafayette and state of Wisconsin, have invented certain Improvements in the Method of Suppressing Horns in Cattle, of which the following is a specification. * * *

The object of my invention is to avoid the troubles and dangers attending the removal of a fully developed horn; and to this end it consists in effecting by chemical means the suppression of the horns while still in an embryotic or incipient stage. I have found after many experiments that it is possible by properly treating the young horn to arrest its growth, and this without in any way affecting or impairing the health or appearance of the animal in other respects. I have found that various chemicals and chemical compounds may be employed to accomplish my end.

* "Dehorning Calves," *Indiana Farmer*, Feb. 6, 1892.

I recommend, however, the following composition of matter : concentrated potash, one hundred parts ; water, one hundred and ninety parts ; logwood, ten parts. The essential element of the composition is the potash, which may be used without logwood and of any suitable degree of attenuation.

" In practice I commonly make use of the solution when the animal is from one to ten days of age. It is simply applied externally to the young or incipient horn by means of a brush or other instrument, and in most cases I find that a single application is sufficient to answer the purpose in view. * * *

Having thus described my invention, what I claim is : 1. The improvement in the art of suppressing horns in cattle, consisting in applying to the incipient horn a substance, substantially as described, to check its growth. 2. The improvement in the art of suppressing or eliminating horns in cattle, consisting in treating the incipient horn with potash, substantially as herein described."

The " Dehorner " was submitted to the Station Chemist, Mr. G. W. Cavanaugh, for analysis and his report is as follows :

" The sample of chemical Dehorner has been found on analysis in this laboratory to consist of a solution of 32.25 per cent. of caustic soda in water. Caustic soda is worth 15 cents per pound and one pound would make about 1 litre of solution of the above strength. The bottle contains 1-10 litre and therefore the amount in the bottle would cost about 1½ cents."

The price given in the circular is \$1.00 per bottle.

Concerning the efficacy of the " Dehorner " there can be little doubt ; caustic soda is almost identical with caustic potash in its caustic properties and our experiments and those of others have shown caustic potash to be effective in preventing the growth of horns.* Moreover, experiments at the Wisconsin Agricultural Experiment Station have shown that the March Dehorner will do what is claimed for it.

We are therefore inclined to the following conclusions :

1st. The John March Company's Chemical Dehorner is undoubtedly effective for the purpose intended.

2d. It is not made of the materials called for in the specifications of the letters patent.

3d. It is sold at an exorbitant price.

4th. There need be little fear of infringement of a patented article consisting of a single well known chemical reagent, or of a method already so well known and advertised. I. P. ROBERTS.

*8th Annual Rept. of Agric. Expt. Station of the Univer. of Wisconsin, p. 289.

Bulletin 55.

July, 1893.

Cornell University Agricultural Experiment Station.

HORTICULTURAL DIVISION.

GREENHOUSE NOTES

FOR 1892-93.

- I. Third Report upon Electro-Horticulture.**
- II. Winter Cauliflowers.**
- III. Second Report upon Steam and Hot-Water Heating.**



By L. H. BAILEY.

PUBLISHED BY THE UNIVERSITY.

ITHACA, N. Y.

1893.

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BULLETINS OF 1893.

50. The Bud Moth.
51. Four New Types of Fruits.
52. Cost of Milk Production.—Variation in Individual Cows.
53. Œdema of the Tomato.
54. Dehorning.
55. Greenhouse Notes.

I. THE PROFITS OF SPRAYING APPLE ORCHARDS.

Spraying orchards to protect the foliage and fruit from the attacks of insects and fungi may now be considered as one of the regular duties connected with the growing of apples. Those who have had experience in this direction are practically unanimous in saying that not only does it pay to spray apple orchards but it generally pays well. Doubts as to the advisability of making applications to orchards are rapidly disappearing, and now arise the questions, what to apply, and how and when to make the applications. The following experiments were designed to indicate as accurately as possible what are the best methods of treating apple orchards so that fruit of the best quality may be obtained with the smallest outlay of labor and money.

Description of the orchard used in the experiments of 1892 and 1893. The orchard of John J. McGowen was selected for the work. This orchard covers about two acres and is situated upon a strong clay loam. The land is moderately rolling so that fairly good drainage is afforded. The trees were set in 1869, making the orchard now twenty-four years old. However, many of the trees first set have died at varying intervals so that the orchard is not uniform. Most of the trees used for filling vacant places are Baldwin, and many of these are now coming into bearing. Nearly one-half of the trees originally set and now in bearing are King; the other varieties in full bearing are Baldwin, Fall Pippin, Maiden Blush, Fallawater, Red Astrachan, Chenango Strawberry, and Westfield Seek-no-further. The last two varieties were not used in the experiments.

The care which the orchard received from the time of setting has been as follows: During the first three years the land between the rows of trees was used for raising grain and hay. It

was then seeded down and sheep were put in. The sod has not been broken since it was first formed. The trees have had an annual dressing of about a quarter of a load of barnyard manure per tree until the year 1890, when the quantity was increased to about a third of a load. The trees, as a rule, have been regularly pruned and the old ones are now, with scarcely an exception, fine specimens of the varieties which they represent.

The orchard has borne irregularly. What may be called the first crop was obtained in 1884. The yield was then large, possibly larger than the trees should have been allowed to bear, for on an average, about fifteen bushels per tree were harvested from the King. During the following years the crops were exceedingly light, but this year the orchard produced over three-fourths of a crop.

The orchard was sprayed for the first time in 1890. London purple was then applied at the rate of one pound to two hundred gallons of water. The first application was made about the time the blossoms fell from the trees, and the second about two weeks later. In 1891 only one application was made to the orchard, London purple being used as before. The first experiments carried on under the direction of this station were made in 1892. The entire orchard was then treated with various fungicides and insecticides.* Some of the results obtained indicated the lines of work followed during the present year.

Apple scab.—The apple scab fungus is probably the most serious enemy of the apple grower. It has been determined that this fungus is active even before the leaf buds open, and that the little apples are attacked as soon as the flowers open, and probably even earlier. We have still to learn at what season the growth of the fungus practically ceases, and during what period the apples and leaves are most liable to its attacks. This may be determined in two ways: first, by studying the life history of the fungus, and second, by applying fungicides at intervals to the trees. If the last method is followed very thoroughly the results may be obscured by the more or less complete extermination early in the season of the fungus in the treated orchard. But if a few thor-

* See Cornell Experiment Station Bulletin, No. 48, December, 1892.

ough applications made at the proper time will prove to be sufficient to protect the trees, the fact that the trees are thus protected is of great practical value, whatever the natural life history of the fungus may be.

Points of merit in fungicides.—The relative merits of the most important fungicides now in use still require careful consideration. Cost, ease in preparing and applying, adhesive power, all must enter into any comparison which may be made; and of late a still more important factor has been added, namely, the readiness with which the fungicide may be applied in combination with the arsenites. The fungicide which surpasses in all the above points has still to be discovered, but some now in use possess most of them. Spraying need not be neglected from a want of effective material.

Spraying machinery.—The machinery to use in orchard work is an important item. Spraying is hard work, unless the pump is run by horse power, and this can be used with profit only by owners of exceptionally large orchards. The vast majority of apple growers are necessarily forced to use hand pumps. These are now offered by the trade in almost endless variety, and selections are often difficult. Pumps of various descriptions have been tried at this station and the following are some of the points which have been emphasized.

The pump should be powerful. It requires double the amount of exertion to apply a given amount of liquid with a small pump than is necessary when one of ample size is used. In general, a pump used for orchard work should have a cylinder at least two and one-half inches in diameter, the stroke being from four to five inches in length. The handle should be long, as greater power can then be obtained. Working parts which are exposed to the action of the materials applied should be of brass, or else brass lined, for iron soon corrodes. The air chamber should be rather small, especially if the pressure of the liquid can be utilized in keeping the nozzle free from obstructions. In such cases, the one who pumps should be able to increase the pressure of the liquid in the nozzle by one or two quick strokes of the handle. A large air chamber defeats this. The pump used in the following experiment was the Gould "Standard" No. 2. It worked

satisfactorily, but is open to the objection of being rather small, especially when much work has to be done. It is manufactured by the Gould Co., of Seneca Falls, N. Y.

Many pumps are supplied with agitators, but these have not proved so satisfactory as was hoped. It was found that those which stirred the liquid by means of a stream which was discharged from a return pipe near the bottom of the barrel did not keep the liquid in the entire barrel stirred, but only in that portion of it which came directly under the influence of the current. Another objection to this class of agitators is that too much power is lost. Paddles of various kinds have been recommended. They are attached to the pump handle and with each stroke pass through a certain portion of the liquid. These do better work than the agitators mentioned above, but they also require considerable power. No agitators were used in making the applications mentioned in the following pages. The liquids were stirred with a stick as often as was necessary, which was commonly before each tree was begun.

The Improved McGowen nozzle No. 7 is the one used throughout the season. It is manufactured by John J. McGowen, of Ithaca, N. Y. The spray thrown is fine and forcible, and the nozzle gave no trouble from clogging. The pump was fastened to a barrel which was turned upon its side. The barrel was then placed in a light wagon and filled through a hole about six inches square situated at one side of the pump. The liquid was directed into it by means of a wooden funnel. Two persons worked together in making the applications; one drove and directed the spray, while the other pumped.

Distance of planting apple trees.—The trees of this orchard are set forty-two feet apart each way. The advisability of planting those varieties of apples which have spreading tops like King and Baldwin at least forty feet apart cannot be too strongly emphasized. Sufficient room for the passage of a wagon must be allowed between the rows when the trees are full grown, and even forty feet is not sufficient for some varieties. A closely set orchard can be sprayed only with great difficulty, and an unsprayed orchard is rarely a profitable one unless it is situated in a peculiarly favorable locality, or unless it consists of varieties which are

practically scab and worm proof. The greater ease with which an orchard may be sprayed when in full bearing is of itself a sufficient argument for open planting in apple orchards.

Amount of liquid used.—The amount of liquid applied to the large trees at each application averaged about four gallons. If less liquid was used it was found to be insufficient to cover all parts of the tree as thoroughly as was desired; when more was used, most of the excess fell from the tree to the ground and was lost. The number of trees which may be treated in a day with the outfit described above is about one hundred and twenty-five. In experimental work much time is necessarily lost, but this estimate is not far from the number of trees which may be well sprayed by regular work.

The weather.—The spring and summer of the year 1893 were, on the whole, normal. The departure from the average rain fall of each month was as follows: April + 1.69 inch, May + 2.01 inch, June — 1.57 inch, July + 1.20 inch. April and May show an increase, May particularly so. As the temperature during these months was practically normal, the apple scab fungus met favorable conditions for its development. June was inclined to be dry, although considerable rain fell; but July shows a rainfall above the average. The work done the past season was consequently subjected to practically the same conditions which may be expected any year.

Materials used. The following are the materials applied to the orchard. They were used singly and also in combination.

Bordeaux mixture,
Ammoniacal copper carbonate,
Fostite,
Paris green,
London purple.

The Bordeaux mixture was prepared according to the formula:

Copper sulphate, 6 pounds,
Quick lime, 4 pounds,
Water, 40 gallons.

The sulphate of copper was bought in the crystalline form. It was dissolved by placing the six pounds in a bag of coarse material and suspending it in the top of a pail filled with water. Treated in this manner the crystals dissolve in an hour or two.

If hot water is used they enter into solution much more rapidly. The lime was generally slaked in about a pail of water. Then these two liquids were poured into a keg holding eight gallons, and a pailful of water was added. In this manner six gallons of concentrated Bordeaux mixture were obtained. If the entire amount was to be used, it was poured into a barrel holding forty-five gallons and sufficient water was added to make forty gallons of the mixture. If only a small quantity of the Bordeaux was desired, it was made by taking one part of the concentrated mixture and adding to this nearly six parts of water. In this manner a mixture of very uniform strength was obtained. It was allowed to stand a few hours before using. When prepared according to the above formula, the cost of a gallon of Bordeaux mixture is about one and one-fifth cents.

The ammoniacal carbonate of copper was made as follows :

Carbonate of copper, 5 ounces,
Ammonia 26°, 3 to 5 pints,
Water, 40 gallons.

The amount of ammonia varied, for it could not be obtained of uniform strength. Consequently the above formula was usually modified and the fungicide was made by taking :

Carbonate of copper, 1 ounce,
Ammonia, enough to dissolve the copper carbonate,
Water, 9 gallons.

This formula has proved to be a very convenient one. Although the solution is a trifle weaker than the one first given, it is of the same strength as that recommended by the Division of Vegetable Pathology, at Washington. The cost, when thus prepared, is about one cent per gallon. This fungicide was used during the entire season in combination with Paris green. To forty gallons of the ammoniacal copper carbonate of the strength given above there were added :

Paris green, $2\frac{1}{2}$ ounces.
Quick lime, $\frac{1}{2}$ pound.

The lime was previously slaked in water and then both ingredients were added to the copper solution immediately before the applications were made.

Fostite is a very fine, bluish gray powder (see page 287). It was applied to the trees by means of a bellows furnished us by

C. H. Joosten, 3 Coenties Slip, New York City. The discharge pipe of the bellows was entirely too short to reach the tops of the trees, but a fairly uniform application could be made by climbing into the tree and then blowing the powder at short range. This method is, of course, impracticable for commercial work. Fostite is sold in one hundred pound lots for \$6.50, but larger quantities are sold at a lower rate.

Paris green was used at the rate of two and one half ounces to forty gallons of water, which is about the same as one pound to two hundred and fifty-six gallons of water. London purple was used in the same proportions as the Paris green.

Objects of the experiments.—The above materials were applied with the intention of observing the following points :

1. The number of applications of fungicides and insecticides necessary to produce fair fruit.
2. The comparative values of the fungicides.
3. The comparative values of the insecticides, and the advisability of applying them in combination with fungicides.

Division of the orchard and dates of applications.—The orchard was divided so that some trees should be sprayed two times, others four times, and some even six times. Those sprayed twice received the first application May 19, and the second June 8. On the former date the first blossoms had just opened, only about a dozen being noticed, all upon King trees. At the time of the second treatment a few blossoms still persisted upon the trees. At first the intention was to have a shorter interval between the two applications, but the season advanced so slowly that it was thought advisable to wait. The trees which were sprayed four times were treated April 26, May 19, June 8, and June 22. When the first application was made, the buds upon the trees were swollen and almost ready to burst, but their winter covering still surrounded them more or less completely. In our experiments of last year the necessity for early applications was strongly indicated. On June 22, at the time of the fourth application, the young apples had set and active growth had begun.

The third lot, the one receiving six applications, was sprayed on the same dates as the preceding, but in addition the trees were sprayed July 13, and again August 1. In this manner the fruit

and foliage were well protected during almost the entire season.

Combinations used.—The trees upon which fostite was applied, were also selected for the comparative test of London purple and Paris green. The powder was applied with a bellows, which necessitated the separate application of the insecticides. These were applied June 8 and 22, the dates of the first two applications following the fall of the blossoms from the trees. Upon the same dates Paris green was also used in combination with the Bordeaux mixture. Otherwise the Bordeaux was used alone.

The ammoniacal carbonate of copper was invariably applied in combination with Paris green according to the formula given on page 262. Paris green readily dissolves in ammonia and it was hoped to avoid the caustic action of this solution by the addition of lime. Paris green was also applied alone to test its value as a fungicide.

Grading of the apples.—The apples were harvested about the middle of September. The yield from each tree was placed in separate piles so that it could be accurately examined, and the effects of the various applications noted. The picked fruit was divided into three grades, the windfalls being so few in number that they were not taken into consideration. The standard for the first grade was high. It was the intention to have this grade composed entirely of fancy fruit, and only strictly first-class apples were put into it. The amount of scab or other fungous injury upon an apple determined its grade, the injury done by worms being rather secondary, for the apples were comparatively little damaged by them. As a rule, large and symmetrical apples possessing good color, were placed among the seconds if several diseased spots could be found upon their surfaces even if the spots were small; for such spots showed that fungi had succeeded in entering the apples, and this was just the result which the applications were designed to prevent.

Consequently, the grading was not done entirely upon a commercial basis, for many of the apples which were counted as seconds might have entered the market as fancy fruit, because the injury done them was not great enough to cause any apparent disfigurement. The apples which constituted the third grade were extra specimens of cider apples, and they are so considered

in the table on page 266 ; but they averaged as good as the ordinary barreling apples of the country.

In counting the number of apples which were wormy, some difficulty was at first experienced. All were not injured to the same extent by the larvæ of the codlin moth, these being the particular ones sought. When an apple had been attacked early in the season the injury done could be seen at a glance. But young larvæ were abundant during late summer and early fall. Many of them had hardly begun their destructive careers, so that practically the apples were uninjured, although the cause for future injury was present. Such apples were nevertheless considered as wormy and were graded second class.

For convenience in comparison, all the figures in the following pages show percentages. The first column, and the ones giving the weight of the fruit, are of course excepted.

The results from only three varieties are tabulated. Some of the other varieties contained in the orchard produced no fruit. Others, especially the Red Astrachan, could not be obtained to make comparisons as the fruit was sold as soon as it was fit for market. In general, however, this variety gave nearly as marked results as those obtained from the Fall Pippin or the Maiden Blush. A third reason for omitting certain varieties from the table is that no definite results were obtained. This subject is more fully treated on page 268.

Unsprayed plots.—Two King trees, situated in different parts of the orchard, were used as checks in order to have a substantial basis with which to compare the results obtained from the sprayed trees of this variety. One-half of a Fall Pippin tree was used as a check, there being only four trees of this variety in the orchard. The orchard contains but one tree of Maiden Blush, so that only one-half of this could be used as a check. However, from the appearance of other apples of these last two varieties, borne in the neighborhood, the fruit produced upon the unsprayed portions showed well the comparative value of untreated apples.

This table contains in a condensed form the principal results obtained this year in the orchard of Mr. McGowen, and it is the basis for many of the conclusions which follow. But additional tables are necessary in order to realize the full force of many of the figures, and to compare in a more convenient form various results obtained.

Number of applications necessary.—To reply to the question, How many applications can be applied with profit? is not an easy task. Too many factors must be taken into consideration to give an answer which will apply to all apple growers. It can be shown what the results of varying numbers of treatments have been, and from this each grower must decide for himself how many can be made with profit. The percentages of gain in first-class apples of the sprayed over the unsprayed portions are given below :

TABLE II—SHOWING PERCENTAGES OF GAIN IN FIRST-CLASS APPLES OBTAINED FROM VARYING NUMBERS OF APPLICATIONS.

Number of applications.	King.					Average, omitting Fostite plats.	Fall Pippin.					Maiden Blush.	General average gain.
	Bordeaux mixture.	Am. carb. copper.	Fostite and Paris green.	Fostite and London Purple.	Paris green.		Bordeaux mixture.	Am. Carb. copper.	Fostite and Paris green.	Paris green.	Average.	Bordeaux mixture.	
2	120	80			92	97							97
4	112	100			132	115						220	141
6	204	128	60	32	128	150	6000	2200	600	2900	2925		1361

This table emphasizes several facts. In the first place, it shows what an enormous range of variations is found in the treated apples of different varieties. The series is most nearly complete in the King, but the Fall Pippin shows the benefits of six applications, and the Maiden Blush of four. The last was more affected by four applications than the Kings by six, and undoubtedly the Fall Pippin would have shown a still greater difference judging from the effect produced by six applications.

Turning to the King, it will be seen that on the average two applications increased the number of first-class apples 92 per cent., four applications 115 per cent., and six applications 150 per cent. In making these averages, only the application of Bordeaux mixture, ammoniacal copper carbonate, and Paris green were considered, for it would be obviously unfair to include fostite under the six applications and not under the others. This fungicide was applied merely for the purpose of determining its value as compared with the others.

It is practically impossible to show by means of figures the exact condition of an apple crop. The averages for the King, and these were the ones particularly selected to determine the benefits derived from different number of applications, show a uniform and marked increase in the number of first class apples as the number of applications increased. As has already been said, the grading was not done for the ordinary market, but for fancy trade, and since the later applications protected the fruit from attacks of scab which would have produced but slight blemishes, the above figures must not be construed to show that it is much better for the general grower to make six applications instead of four.

The commercial grading of all the Kings as made by the buyer was as follows. The total yield of King was 65 barrels. Of these, 59 barrels were marked as firsts, $4\frac{1}{2}$ as seconds, and $1\frac{1}{2}$ barrels as thirds. On considering the percentages of the three grades, they constituted respectively 91, 7, and 2 per cent. of the total yield. In this grading the wind-falls were also included, which was not the case in the table on page 266. The highest per cent. of first-class fruit shown by this table was 76, yielded by King apples sprayed six times with the Bordeaux mixture. Some idea of the high standard set may be obtained by comparing this with 91 per cent. made in packing.

Value of sprays upon different varieties.—Two important factors must be considered in spraying every orchard. The first and more important one has to do with the varieties grown; the second has reference to the characters of the season. During wet weather more applications are necessary than when the rainfall is slight. Dry seasons do not favor the development of injurious fungi, and the materials applied remain upon the trees much longer, not being washed off by rains.

Some varieties are undoubtedly much more subject to the attacks of apple scab than others. The past season proved this beyond a doubt as regards the varieties grown in the treated orchard. Several trees of Baldwin and Fallawater were included in the experiments, but no detailed report is here made of the results obtained, as there was practically no difference between treated and untreated trees. Although the Fall Pippin and the Maiden Blush apples were nearly ruined when not treated, Baldwin and Fallawater apples growing close by them were hardly injured. I believe it can safely be said that the susceptible varieties mentioned above could have been sprayed with profit four or five times in order to reduce insect and fungous injury, while the comparatively resistant varieties would not have repaid any more applications than those necessary to control the codlin moth, two treatments with Paris green being probably sufficient for this purpose.

Another point bearing upon this subject cannot be overlooked. Many varieties are not uniformly attacked in different localities. It may pay some growers of a certain apple to spray it thoroughly, while the same variety in another locality would not warrant the expense of even one treatment for scab. During the summer of 1892, an attempt was made to determine the amount of injury done by the scab to the varieties of apples now in cultivation. The results of the work were published in Bulletin No. 48, of this Station. Although the list given is not so complete as might be wished, it is still of interest in this connection.

From the preceding it will be seen that no rule regarding the number of applications nor the dates upon which they are to be made can be laid down with safety. Each grower must be his own judge. If two, four, or six applications are decided upon, they can be applied with safety and profit, in New York, upon dates given on page 263, subject to the condition of the season.

Comparative efficacy of the fungicides.—A fair idea of the comparative values of the various fungicides used can be obtained by examining the number of first-class apples produced by the trees sprayed six times with the fungicide used in each plot.

TABLE III—SHOWING THE PER CENT. OF FIRST CLASS APPLES PRODUCED IN THE DIFFERENT PLOTS.

Treatment.	Per cent. of first class apples of each variety.			Per cent. increase of each variety.		
	King.	Fall Pip-pin.	Maiden Blush.	King.	Fall Pip-pin.	Maiden Blush.
Unsprayed	25	1	15			
Bordeaux	76	61	48	204	6000	2200
Am. carb. copper.....	57	23		128	2200	
Paris green	57	30		128	2900	
Fostite and Paris green	40	7		60	600	
Fostite and London purple	33	.		32		

The decided superiority of the Bordeaux mixture can be seen at a glance. In no case did any other fungicide give results which approached in excellence those obtained from this mixture. Nor is its value fully shown by the number of apples in the various grades, for the general appearance of these apples was so superior that the fruit of the Bordeaux lots could be identified at sight almost with certainty. This superior appearance was mainly due to the uniform size of the apples, their regular form, and the smoothness of the skin. Fig. 1 illustrates these points well. The regularity with which the first-class apples could be piled upon the trays is particularly to be noticed. Little remains to be desired as regards uniformity of fruit.

The general effect of six applications upon King and Fall Pip-pin apples may be obtained by comparing Figs. 1 and 3, these representing treated apples, with Figs. 2 and 4 showing fruit which was not sprayed. With the more susceptible varieties it is evidently a question of crop or no crop, and the answer is in the hands of the grower. In comparing the illustrations it must be borne in mind that among the sprayed lots were a great many apples graded as seconds, which really were first-class apples, only they did not bear the test of sufficient freedom from scab. The general appearance of the seconds of the unsprayed lots was markedly inferior to the same grade of the sprayed lots.

The ammoniacal carbonate of copper most nearly approached the



FIG. 1.—*King*, sprayed six times with Bordeaux mixture. Showing relative proportion of first, second, and third grades respectively.



FIG. 2.—*King*, not sprayed. Showing proportions of first, second, and third grades respectively.



FIG. 3.—*Fall Pippin*, sprayed six times with Bordeaux mixture. *First, second, and third grades.*



FIG. 4.—*Fall Pippin*, not sprayed. *Showing first, second, and third grades.*

Bordeaux mixture in the value of the results obtained. Although the average increase of first-class apples, 128 per cent., is the same as that given by Paris green, still the general appearance of the apples treated by Paris green and carbonate was plainly in favor of those treated with the ammoniacal solution. The first-class apples of this last were almost equal to the same grade of those treated with Bordeaux, while those treated with Paris green were not. More small spots of scab could be found upon the latter and the apples were unquestionably inferior. However, in the general market most of them would have been classed as firsts.

Fostite is far behind in the comparison. King trees to which this powder was applied, when treated with Paris green for the codlin moth, show an increase of 60 per cent. of first-class apples. When the London purple combination was used, the increase is but 33 per cent. Since the Paris green undoubtedly assisted in keeping the fruit fair, the entire gain in the other lot may be ascribed to Fostite, for London purple has practically no value as a fungicide. But this test of Fostite is not entirely fair, since the apparatus for applying it was poorly adapted to the work.

The following diagrams will assist in showing more plainly the results obtained from six applications of various fungicides upon King and Fall Pippin apples. In diagram II, which refers to Fall Pippin apples, the upper division represents first-class apples, the middle division second-class, and the lower one third-class apples.

DIAGRAM I. SHOWING THE RELATIVE VALUES OF THE FUNGICIDES APPLIED TO KING APPLES.

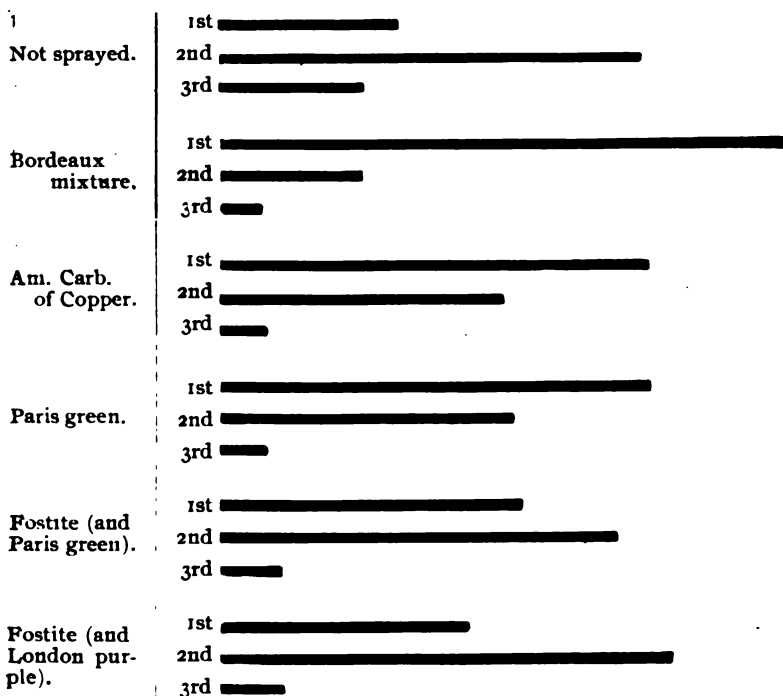
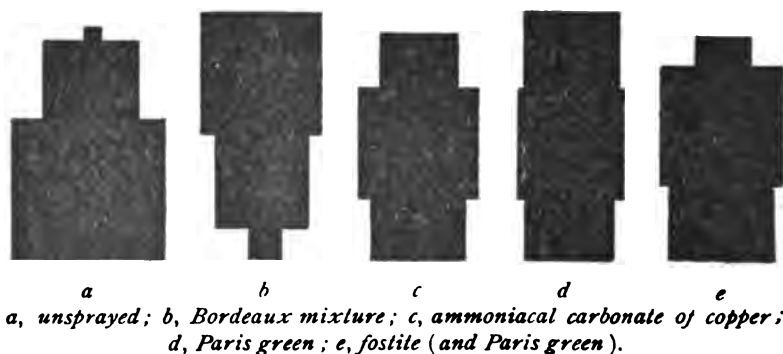


DIAGRAM II. SHOWING THE RELATIVE VALUE OF THE FUNGICIDES APPLIED TO FALL PIPPIN APPLES.



None of the apples showed the effects of spraying more plainly than the Fall Pippin. This variety is very subject to the attacks of scab, and diagram II shows clearly the comparative values of the fungicides, as well as the benefits derived from proper applications. By comparing the untreated plot with the Bordeaux, it will be seen that the second one (*b*) is practically the reverse of the first (*a*). The unsprayed Fall Pippin yielded scarcely a first-class apple, the bulk of the crop being third-class. The apples treated with Bordeaux are mostly first-class apples, while the proportion of thirds is exceedingly small. Certainly it pays to spray this variety.

Insecticidal values of the arsenites.—Although the London purple and the Paris green used in these experiments contain about the same amounts of arsenic, still it is held in different forms. Applications were made to determine their comparative values.

TABLE IV—SHOWING THE RESULTS OBTAINED FROM APPLICATIONS OF THE ARSENITES.

	King.				Fall Pippin.			Maiden Blush.	
No. of treatments	1	2	6	0	2	6	0	2	0
Materials applied.	Per cent. of wormy fruit.								
Bordeaux mixture.....	11	5		9	4		12	2	13
Am. carb. copper.....	9	7	5	9		2	12		
Paris green	5	6	3	9	3	2	12		
London purple		3		9					

The apples were on the whole very free from worms, whether sprayed or not, yet the above table indicates some of the effects of the applications.

The per cent. of wormy apples among those sprayed but once with Bordeaux, is large when compared with the apples which were not sprayed. In one case, the number is larger, but on the average a small gain was made. This application was made June 8, as soon as the blossoms had fallen from the trees.

All varieties show a considerable decrease in the number of

wormy apples when the trees were treated twice. The second application was made June 22, two weeks after the first. These two treatments protected the apples so well that any additional ones would hardly have been profitable. June was comparatively dry (see p. 261), but the rain-fall during July was considerably above the average, so that the poison stood a good chance of being washed from the trees. It would scarcely seem to be advisable to apply Paris green or London purple more than twice in a season for the codlin moth, unless the rain-fall is very heavy or continuous. Late applications protect the fruit from larvæ which hatch late in the season, but their numbers are comparatively few, and the damage done is so insignificant from a financial standpoint that the returns will scarcely warrant the expense.

On the whole, it appears to be immaterial in which form or combination the arsenites are applied. The table shows that when only one application was made Paris green gave better results when applied alone than when applied in combination with Bordeaux. But when two applications were made this result is reversed. This coincides practically with the results obtained in 1892,* when it was also found that the action of the poison was not materially affected by the presence of the Bordeaux mixture.

Paris green and the ammoniacal solution did not give such favorable results, but as the difference is comparatively slight, conclusions adverse to the combination can scarcely be drawn.

Two applications of London purple made upon the King gave more sound apples than two of Paris green, only 3 per cent. being found wormy. But Paris green equals this in two applications made upon Fall Pippin, and surpasses it by 1 per cent. in the Maiden Blush. Consequently, no preference can be given to either poison as regards its insecticidal value. It is probable that if each contains the same amount of arsenic, the value of the two is the same. In one respect, however, Paris green has been disappointing. It was found last year, and again this summer, that the foliage of apple trees is more or less injured by its use. When many applications are made, using 1 pound of the poison to 256 gallons of water, the injury may become serious. After

* See Cornell Experiment Station Bulletin No. 48, December, 1892.

the fourth application had been made to the orchard, it was found advisable to use about a quarter of a pound of quick lime, first slaked in water, to every forty gallons of the poison mixture. This apparently stopped the caustic action of the Paris green. Samples of Paris green from several manufacturers are now being analyzed by the Station chemist, and from incomplete data it would seem that all Paris green now sold in the market contains more or less soluble arsenic. If trouble is experienced in its use, the addition of lime will be sufficient protection to the foliage. London purple also injured the foliage, even to a greater extent than did the Paris green, but the injury was partially obscured by the action of fostite, which was applied upon the same trees.

Action of fungicides upon foliage.—Fostite was applied to the trees in liberal quantities, in order to give it a fair trial. The lower branches of the trees received their full share, which was not always the case with the upper ones. Later in the season the leaves upon the lower branches showed decided injury, so that if this powder still proves to be of value for combatting apple-scab, it must be used with caution.

The ammoniacal carbonate of copper, to which was regularly added Paris green and lime as described on page 262, proved very satisfactory as regards injury to foliage. Throughout the season the leaves of trees treated with this combination were healthy and the trees looked vigorous. The Bordeaux mixture also protected the foliage so well that scarcely a diseased leaf could be found. This effect was particularly noticeable on the Fall Pippin. The difference in foliage between the sprayed and unsprayed trees could be seen very plainly. The foliage of this variety is naturally much attacked by the apple-scab fungus, and this characteristic allowed the beneficial action of the fungicide to become apparent. The foliage of a Fall Pippin tree that was sprayed with Paris green was also noticeably more healthy than the unsprayed.

Size and color of the sprayed fruit.—The size of the apples was in some cases very plainly affected by the applications, and possibly also the color. On this latter point there was a difference of opinion, just before the apples were picked. The apples were sold while still upon the trees and the buyer very soon discovered an unsprayed tree and wanted to know what was the matter with

it. It was his opinion that the color of the sprayed fruit was deeper and brighter, and others affirmed the same, but the point is open to doubt. Many varieties of apples will color beautifully if the sun is allowed to shine upon them even after they are picked.

But there can be no question of increased size of the sprayed apples. The Kings did not show it so plainly from the fact that the entire trees received the same treatment. By referring to the table on page 266 it will be noticed that the weight of one hundred apples sprayed twice with Bordeaux mixture was $37\frac{1}{2}$ pounds, sprayed four times $47\frac{1}{2}$ pounds, sprayed six times $44\frac{1}{2}$ pounds. There is apparently no connection between the weight of the fruit and the treatment of the trees, and the other weights given under this variety are equally disconnected. An accurate comparison can be made in case of the Pippins. In the table mentioned, the numbers in the division which refers to the portion treated with Fostite and Paris green were obtained from trees treated only upon one side, the other half remaining as a check. The gain in weight is shown to be $3\frac{1}{2}$ pounds, although the treated apples were by no means the best. But the Maiden Blush apples showed what could be done. There is only one tree of this variety in the orchard, and this year it bore a fair crop. One-half of this tree was sprayed with Bordeaux and the other half was not touched. When harvested, 100 average apples of the unsprayed side weighed $24\frac{1}{2}$ pounds, while an equal number similarly chosen from the other half of the tree weighed $37\frac{3}{4}$ pounds; a gain of over 54 per cent. This difference was forcibly shown in another way; in fact, so plainly and conclusively did it show the value of spraying apples susceptible to the attacks of the scab that it alone would convince the most skeptical that the operation is a paying one. One hundred average unsprayed apples filled a half-bushel basket evenly full, as shown on the cover page; one hundred of the average sprayed apples filled a bushel basket evenly full. Thus the bulk of the crop of Maiden Blush was practically doubled. At the same time, the energy of the trees was taxed but little more, as the production of the seed in the apple is more exhaustive than the production of the flesh. It is true that but few commercial varieties of apples will respond so generously to

treatment, but still some will, and there can be no doubt that all varieties attacked by fungus are more or less checked in their growth. In addition to this, healthy foliage assists in making a healthy and vigorous tree, resulting in the deflection of a greater amount of food to the fruit.

Keeping qualities of apples as affected by sprays.—A few Fall Pippin and Maiden Blush apples were selected from the sprayed and also from the unsprayed portion of the trees, about September 20. Bordeaux mixture had been used upon the former. They were stored in a cool dry cellar. On the 15th of October the unsprayed apples began to show signs of shriveling. The scabby portions were depressed and some days later showed signs of decay. November 18, the unsprayed apples were much shrivelled and somewhat decayed. The sprayed apples, which were exceptionally fine specimens, were still plump and fit for market. It is possible that the keeping qualities of apples may be considerably affected by proper applications.

It will undoubtedly be interesting to follow the apples from this orchard into the markets, and thus determine what relation the spraying of the fruit bore to the price received for it. Through the kindness of the buyer, J. H. Gail, commission merchant in Buffalo, N. Y., I am able to give his report on this point. His statement regarding the appearance of the fruit in the orchard was as follows :

“ Without question, the showing of the fruit, before harvesting, in the apple orchard of John J. McGowen was one of the finest it has ever been my pleasure to see. The fruit, having been picked and barrelled for extra fancy trade, did not show over two or three per cent. of culls; and the culled fruit when packed made a very good grade of second quality. There was practically no fruit, usually known as cider apples, in the orchard.”

The following letter relates to the sale of the apples in Buffalo :

“ The apples were as fine as anything I ever saw in the shape of Kings, even those rated as 2nd's or No. 2's being as good as the ordinary run of No. 1 fruit; in fact, they sold at the price of other No. 1's. We commenced the trade on them as soon as they arrived here, to some of our buyers of fancy fruit, at \$4.50 per bbl. in job lots. I think had we put the price at \$5.00 we should have got it; in fact we did get it for a portion of them.”

while the ordinary run of Kings and so-called No. 1's sold in single barrel lots at the same time at \$3.75 to \$4.00. We think they went out fully \$1.00 per bbl. better than the average run of Kings, and all who had them were anxious for more."

Buffalo, N. Y., Nov. 14, 1893.

J. H. GAIL.

The following letters indicate the attitude of leading fruit growers of this state regarding the spraying of orchards:

"In my opinion, spraying is a work of inestimable value; indeed I believe no man engaged in growing apples can afford to dispense with it. He should spray both with reference to the work of insect life and fungi. It should be done at least twice in the season and *every year*. The operation is inexpensive, and will pay a larger percentage on the investment than any other outlay of an equal amount."

Geneva, N. Y.

S. D. WILLARD.

"After five years' experience in spraying with insecticides and fungicides, I am sufficiently satisfied to plan for the future to do the work more thoroughly than it has yet been done.

I have found that Paris green not only avoids a large per cent. of the Codlin moth's depredation, but it also has the effect of destroying the tent caterpillars, and other leaf-eating insects that destroy much of the foliage during the period when it is most needed to perfect the development of wood and buds for the following year, as well as the fruit of the present.

There is no doubt, but that much of the failure of the orchards of New York, for the past ten years has been due to insects that have annually denuded the trees of a large amount of foliage, and there has been a formation of fruit-buds of low vitality.

The same effect has been produced, by a steady increase in attacks of apple-scab fungus upon both fruit and foliage which the trees have not been able to resist, and I have seen fruit over entire counties in Western New York fall to the ground, within a week after blooming, from the effects of apple-scab fungus; and the young foliage was as sear as if a frost had injured it.

When using Paris green alone I apply one pound to 250 gallons of water. If used with Bordeaux mixture one pound to 200 gallons.

A very thorough, even distribution of the mixture is more essential than quantity.

I have used four pounds of copper sulphate and three pounds of lime to 50 gallons of water with satisfactory results on apple and particularly so on quince the past season, as also with grapes. These were sprayed three times, with twelve and fifteen days intervening; the fruit was clear in color, and improved in quality.

No fixed time can be set for the spraying. The fruit grower must study the conditions which vary with each season.

Some varieties are more susceptible to fungus attack than others, as the Spitzenburg and Cranberry Pippin, among apples, and the White Doyenne and Flemish Beauty among pears, and these require more thorough treatment than others."

Ghent, N. Y.

GEO. T. POWELL.

"I made one experiment in which about one-sixth of a R. I. Greening tree was sprayed with Paris green, using 1 pound of the poison to 200 gallons of water. As no rain fell soon after this application, a second one was not deemed necessary. When the apples were harvested the sprayed portion yielded 534 sound apples, or 4 bushels; and 48 wormy apples, or about $\frac{1}{4}$ bushel. The unsprayed portion yielded 216 sound apples, or $1\frac{1}{2}$ bushels; and 92 wormy apples, or $\frac{3}{4}$ bushel. Many wormy apples fell from the unsprayed portion during the season, and as this was not the case with the part sprayed, the above figures are very partial to the side that was not sprayed. The sprayed apples were larger, of better color, and showed less scab. The man who came to buy my crop saw the sprayed side of the tree first, and actually gave me 5 cents a barrel extra for *all* my fruit, although most of my orchard consists of green instead of red varieties."

Perville, N. Y.

C. E. CHAPMAN.

II. TEST OF SOME FUNGICIDES AND INSECTICIDES UPON PEACH FOLIAGE.

Peach trees were treated with the following materials for the purpose of determining the extent to which each would injure the foliage :

Bordeaux mixture.—This was prepared according to the formula given on page 261.

Bordeaux mixture and London purple.—The arsenite was used at the rate of 1 pound to 250 gallons of the mixture.

Ammoniacal carbonate of copper, prepared as described on page 262.

Ammoniacal carbonate of copper, Paris green and lime. These materials were used in the proportions stated on page 262.

Paris green, used alone at the rate of 1 pound to 250 gallons of water.

London purple, used at the rate of 1 pound to 300 gallons of water.

Fostite, applied with bellows.

The above materials were applied to the trees three times, and upon the following dates : July 18, August 3, and August 22. The ingredients of the combined insecticides and fungicides were mixed immediately before the applications were made. The table shows the extent of injury resulting from each.

KIND OF TREATMENT AFTER THREE APPLICATIONS HAD BEEN MADE.

Variety treated.	Treatment and per cent. of leaves dropped.						
	Bordeaux mixture.	Bordeaux and London purple.	Ammoniacal carbonate of copper.	Am. carb. of copper and Paris green.	Paris green.	London purple.	Fostite.
Old Mixon..	0	0	75	.....	.....	.....	.....
Crawford .....	.....	.....	.....	10	75	90	0

The above notes were taken September 12, or 21 days after the last application had been made. Notes were also taken August 22, or after only two treatments had been made.

The Bordeaux mixture did not injure the foliage, whether London purple was added or not. As above prepared it is a perfectly safe fungicide to use on peach trees and the addition of London purple does not render it caustic.

Fostite did no injury to the foliage. The reason for this may be that the leaves of the peach are so smooth that the powder will not adhere to them. At least it was difficult to make what may be called a heavy application, as the powder blew through the trees, very little apparently being retained by the leaves. It is also possible that peach leaves are not affected by the caustic action sometimes shown by Fostite.

The ammoniacal copper carbonate, when used alone, seriously injured the foliage after three applications had been made, fully 75 per cent. of the leaves dropped from the trees and the remainder showed injury, more or less serious.

When Paris green and lime were added to the ammoniacal solution two applications showed considerable injury to the foliage. Three applications caused from five to ten per cent. of the leaves to fall, about ten per cent. of them were yellow, but the remainder showed comparatively little injury. Possibly this decrease in the extent of injury may in part be due to the variety treated, but it is scarcely probable that this influence was very great.

The action of Paris green was exceedingly caustic. Two applications caused nearly a fourth of the leaves to drop from the trees, while soon after the third application about 75 per cent. fell to the ground. It is unsafe to use Paris green upon peaches, unless the mixture be made very weak.

London purple did still more damage than Paris green. Fully 90 per cent. of the leaves dropped from the tree after the third application. This result coincides with those previously obtained by various experimenters, particularly those published from this station in 1890.*

* See Cornell Experiment Station Bulletin XVIII, July, 1890, for detailed accounts of London purple and Paris green upon peach foliage. Analyses of these arsenites are also given.

III. SOME NOVEL INSECTICIDES AND FUNGICIDES.

Various substances have been sent to this station for the purpose of having them tested in regard to their value as insecticides and fungicides, and other materials have been suggested by growers who believed that beneficial results have followed their use. In addition to these several other substances were applied the past season, both singly and in combination, in the hope that something might be found that would prove of value. Some of the substances compared had already been used at this station* in similar experiments; those materials which appeared most promising in 1891 were tested a second time this year. But in the majority of cases it was not known what would be the action of the substance upon foliage, so many of the formulas used are not necessarily the best ones for the proper action of the materials mentioned in them. Some applications were too weak and others decidedly too strong, but all indicated more or less distinctly their value as fungicides or insecticides. Many of the materials were believed to possess caustic properties and to these lime was added. The lime was slaked in a small quantity of water, and required amounts of this milk of lime were used. The applications were, as a rule, prepared immediately before being used.

All liquids were applied with a knapsack pump manufactured by W. & B. Douglass, of Middletown, Conn., and a vermorel nozzle with lance. Powders were applied by means of Joosten's magazine bellows.

Difficulty was experienced in making a uniform application of those mixtures which contained much sediment. This was particularly noticeable in the case of the Bordeaux mixture, for this showed very clearly whether it had been applied properly or not. Such mixtures cannot be well agitated in a knapsack pump, so generally the first applications contain the material in a more concentrated form than later ones. As only small quantities of

* Cornell Experiment Station, Bulletin No. 35, December, 1891.

the various mixtures were applied no serious variations took place in the following experiments.

The following are the kinds of plants treated. When but one variety was used the name is given here; in other cases the name of the variety will be mentioned in the tables or text: apple; blackberry, *Agawam*; dewberry, *Lucretia*; gooseberry, *Industry*; raspberry, *Cuthbert*; and quince. At least one plant was used for each application except in the case of the apple, when only one-half of each tree was treated; the other half served as a check.

Unless otherwise stated, the number of applications is six. These were made on the following dates: May 31, June 14, June 29, July 18, August 1, and August 22. Notes on the action of the materials applied were taken July 14 and Sept. 12. This allowed the effects of few and many applications to be compared. The condition of the weather during this time is mentioned on page 261, and in addition it may be said that the rainfall during August was about normal.

The fungi against which the applications were particularly applied were as follows: During the summer of 1892 most of the varieties of apples had suffered from the attacks of the apple scab (*Fusicladium dendriticum*), for this fungus attacks the leaves as well as the fruit. The quinces have also regularly shown the presence of leaf spot (*Entomosporium maculatum*), while raspberries, blackberries and dewberries have been attacked by anthracnose. This year anthracnose could scarcely be found except on the dewberries. The leaves and canes of these plants were quite seriously attacked by this fungus (*Glæosporium necator*). The *Industry* gooseberry is an English variety and is very susceptible to the attacks of mildew (*Sphærotheca Mors-uæ*). It attacks both foliage and fruit, generally rendering the latter unfit for market.

The numbers in the first column of the following tables show approximately the degree to which the foliage was injured by fungi. All the sprayed plants were carefully compared with the unsprayed and the relative degree of injury from this cause noted as accurately as possible, in order to determine the effect of the application. The second column of the tables shows the gain in per cents. of freedom from fungous attack of the sprayed over the

unsprayed portions. In the third column are placed the numbers which show the per cent. of injury done by the applications.

As a rule, the amounts of injury shown by the tables are based upon the results of six applications. When they refer to a fewer number the fact will be mentioned.

No. 1.—Bordeaux mixture.—This was prepared according to the formula on page 261. Its value as a fungicide has been so often proved that its use here is merely for the purpose of comparing the results obtained from other applications with some which may be considered as standards. The comparative value of the materials can thus be more accurately considered.

Plants used.	Unsprayed.	Sprayed.	
	Per cent. injury from fungi.	Per cent. reduction of fungi.	Per cent. injury from applications.
Apple (<i>Baldwin</i>).....	15	85	0
Blackberry.....	0	0	0
Gooseberry.....	20	75	0
Dewberry.....	10	75	0
Quince (<i>Rea's Mammoth</i> ..	15	80	0
Raspberry.....	0	0	0

The dewberries and the quinces showed most plainly the value of the treatments. Most of the other plants were not so seriously attacked, yet the difference between the treated and the untreated plants could be seen.

The Bordeaux mixture when properly applied practically protects the foliage of plants from the attacks of the fungi mentioned on page 283.

No.—2. Copper Chloride.—This fungicide gave good results in 1891, although it was then used too strong. It was used the past season as follows :

- (a) Copper chloride, 1 ounce.
Water, 25 gallons.
- (b) Copper chloride, 2 ounces.
London purple, 1 ½ ounces.
Lime, 1 pound.
Water, 25 gallons.

THE SPRAYING OF ORCHARDS.

Plants used.	Unspray- ed.	Sprayed.			
	Per cent. injury from fungi.	Formula (a).		Formula (b).	
		Per cent. reduction of fungi.	Per cent. injury from ap- plication.	Per cent. reduction of fungi.	Per cent. injury from ap- plication.
Apple (<i>R. I. Greening</i>).....	10	0	5	50	0
Blackberry.....	0	0	5	0	0
Dewberry.....	20	50	0	65	0
Quince (<i>Fall Orange</i>).....	15	35	0	80	0
Raspberry.....	0	0	5	0	0

Copper chloride possesses some value as a fungicide. It cannot be used alone, however, without injuring foliage, and lime must be added to destroy its caustic properties. It is probable that two or three ounces in twenty-five gallons of water is sufficiently strong to give good results. When used at the rate of an ounce to twenty-five gallons of water it reduced the injury from fungi 50 per cent. upon the dewberries, and 35 per cent. on the quinces. When used twice as strong the injury was reduced 75 per cent. and 80 per cent. respectively. At the same time the foliage was uninjured by the application, even though London purple had been added. These results are encouraging for if a fungicide can be found which will equal the Bordeaux mixture, and still be easy of application, much of the trouble which now accompanies spraying will be avoided.

Copper chloride cannot be used as a fungicide to advantage unless the solution is so strong that lime is required to neutralize its caustic action. On the whole it is a promising fungicide.

No 3.—Iron Chloride.—The chloride of iron was applied to the same varieties of plants mentioned under *No. 1*. The following is the formula used :

Iron chloride, 3 ounces.
 London purple, 1 ½ "
 Lime, 1 pound.
 Water, 25 gallons.

The beneficial action of this chemical was so slight that no definite improvement in the foliage could be seen. The quinces

were apparently not benefited, but upon the dewberries the leaves of the sprayed plant seemed to be a trifle more free from fungous attack than the check plants. The combination possessed no caustic properties.

The experiments of the past season show no practical benefit derived from applications of iron chloride.

No. 4.—Zinc chloride.—This chemical was applied both alone and with lime and London purple.

- | | | |
|-----|----------------|-------------|
| (a) | Zinc chloride, | 1 ounce. |
| | Water, | 25 gallons. |
| (b) | Zinc chloride, | 3 ounces. |
| | London purple, | 1½ ounces. |
| | Lime, | 1 pound. |
| | Water, | 25 gallons. |

Formula (a) was used for the first four treatments, the last two containing 3 ounces of the chloride instead of but one. The same varieties of plants mentioned under No. 3 were used, except that the apple tree was a Westfield Seek-no-further.

No beneficial results seemed to follow the use of formula (a), possibly from the fact that the solution was at first too weak. None of the foliage was injured.

Formula (b) gave little better results. The quince and dewberry plants seemed to have healthier foliage where they were sprayed, but injury from fungi was scarcely reduced more than 25 per cent. at the most.

Zinc chloride, when used according to the formulas given above, is not a fungicide which can be applied with profit.

No. 5.—Zinc sulphate.—The following formulas were used :

- | | | |
|-----|----------------|-------------|
| (a) | Zinc sulphate, | 3 ounces. |
| | Water, | 25 gallons. |
| (b) | Zinc sulphate, | 3 ounces. |
| | London purple, | 1½ ounces. |
| | Lime, | 1 pound. |
| | Water, | 25 gallons. |

The varieties of plants treated were the same as the preceding, but the apples used were McIntosh Red. The advantages derived from the applications were so slight as to be practically of

no value. It is probable that greater quantities of the sulphate are necessary. None of the foliage was injured.

Zinc sulphate has thus far proved of no practical value as a fungicide.

No. 6.—Lead acetate.—The formulas according to which this material was used were similar to the preceding.

- | | | |
|-----|----------------|-------------|
| (a) | Lead acetate, | 3 ounces. |
| | Water, | 25 gallons. |
| (b) | Lead acetate, | 3 ounces. |
| | London purple, | 1 ½ ounces. |
| | Lime, | 1 pound. |
| | Water, | 25 gallons. |

In this case the variety of apple was Maiden Blush for formula (a), and Ben Davis for formula (b). The other varieties were the same as those previously mentioned. No marked results followed the treatments.

Lead acetate did not materially reduce the injury done by fungi to the foliage of the treated plants.

No. 7.—Fostite.—Analysis of this powder made by Mr. Cavanaugh, the assistant Station chemist, shows it to contain about 2 per cent. of copper, but the form in which it is found has not yet been determined. The bulk of the powder is composed of soapstone, or steatite, which certainly has the power of adhering to foliage a long time, especially if it is applied while wet. It is the intention to give a complete analysis of this substance in the near future.

Fostite was applied in dry form, and also in water. In the former case Joosten's magazine bellows was used, and the distribution was made as even as possible. When mixed with water it was used as follows :

Fostite, 8 ounces.
Water, 2 gallons.

Two applications were made according to the above formula, but the remaining four treatments were made with a mixture one-half as strong. The following table shows the results :

Plants used.	Un-sprayed.	Sprayed.			
	Per cent. injury from fungi.	Dry form.		In water.	
		Per cent. reduction of fungi.	Per cent. injury from application.	Per cent. reduction of fungi.	Per cent. injury from application.
Apple (<i>Ewalt</i>)	5	25	0	20	25
Blackberry.....	0	0	0	0	15
Dewberry.....	20	60	0	25	0
Gooseberry.....	10	25	0	40	15
Quince, (<i>Rea's Mammoth</i>).....	15	75	0	75	0
Raspberry.....	0	0	0	0	0

This table shows that fostite possesses marked fungicidal properties. The quinces show the greatest difference between the treated and untreated parts, the injury from fungi being reduced about 75 per cent. ; dewberries were also benefitted, and to a less extent gooseberries and apples. When the powder was used in the dry form apparently no injury was done to foliage of any kind. But when it was mixed with water, apples, blackberries and dewberries were more or less burned. This injury was in no case very serious, although it is undesirable.

In addition to the plants above mentioned, fostite was also tested upon roses, forcing cucumbers, and forcing musk-melons.

During August, the roses of Mr. Arthur Boole, of Ithaca, were severely attacked by the common white mildew (*Sphaerotheca pannosa*,). Fostite was applied to about 500 plants consisting of Bride and Mermet roses.

The powder was first applied August 14 and daily applications were made, so that soon all the older leaves were more or less discolored. This treatment was continued until August 26. During this time the plants were growing rapidly and new foliage was quickly formed. In spite of the powder the young rose leaves were attacked to such an extent that it was doubtful if any beneficial results followed the applications. It was Mr. Boole's opinion, after using fostite during the period mentioned, that the benefits derived did not pay for the material and the

labor of applying, for the young leaves showed spots of mildew almost as soon as they unfolded. This result may be partially explained by the fact that young rose leaves do not as a rule assume such a horizontal position as do the old ones; they have a wilted appearance. Their surfaces also seem to be more smooth and glossy. It is very probable that the powder failed to adhere to the young leaves, and these were then open to the attacks of the mildew. In this trial the time was short but the roses were growing so rapidly that the fungicide had a fair chance to protect the young foliage.

Another experiment upon roses was carried on in the rose-house of this station. About twenty-five of the leading market varieties of tea roses were under treatment. When the plants were set in the house some of them showed considerable amounts of mildew, but most of the varieties were free from the disease. Fostite was immediately applied and the foliage was treated every other day. The powder could be seen very plainly upon the older leaves. When the plants started into growth the condition of the new foliage was watched with interest. Mildew appeared upon the young growth to a considerable extent, and although applications were continued for about four weeks no decrease in the amount of mildew could be observed. In neither of these experiments was any distinct injury from the use of fostite noticed.

During the past summer a crop of cucumbers was grown under glass. The varieties grown were Telegraph, Sion House, Duke of Edinburgh, Blanc Hâtif, and White Spine. In July, mildew (*Oidium erysiphoides* var. *Cucurbitarum*) was observed upon some of the foliage, but especially upon Blanc Hâtif and Telegraph leaves. The house was shut up, the plants syringed, and fostite applied by means of a bellows. The amount applied was supposed to be ample but not excessive. No apparent injury following this treatment, it was repeated in a few days. Three days later some of the leaves showed signs of injury and soon all the foliage showed a greater or less amount of scorching. No further applications were made.

In order to test more carefully the exact amount of injury done to the foliage of cucurbitaceous plants, individual plants of forcing musk-melons were dusted by means of a can having a perfo-

rated cover. The varieties treated were particularly adapted to forcing and were as follows: Melon de Malte, Brodé de Malte, Brodé d'Antibes blanc, Brodé olive, Brodé vert. The applications were made about October 1, upon young plants which were growing vigorously. Enough of the powder was used so that it could be plainly seen; the plants were wet at the time. Two days later some signs of injury were observed, and this continued to increase to such an extent that some of the treated leaves were killed, and one plant died. Some of the other plants show the effects of the application to this date, November 20.

The insecticidal value of fostite was tested on a small scale by W. J. McNeil, a student doing advanced work in entomology. He dusted thoroughly some chrysanthemum plants which were infested with plant lice, distributing the powder carefully over the entire plant. In addition to this, some of the lice were removed from the plant, and rolled about in the powder. They were then placed upon a plant which contained none of the pest. The day following these operations the lice were examined collectively and individually, and no trace of injury was shown by any of them.

Fostite possesses some fungicidal value. This was most clearly shown by Rea's Mammoth quince, Lucretia dewberry, Ewalt and King apples.

It must be applied with caution as the leaves of apples, blackberries, dewberries, forcing cucumbers, and forcing musk-melons have been injured by its use.

When dry, it possesses no value as an insecticide which kills by contact.

No. 8.—Boron compounds.—

- | | | |
|-----|---------------|----------------------|
| (a) | Borax, | 2 ounces. |
| | Water, | 2 gallons. |
| (b) | Borax, | 2 ounces. |
| | Lime, | $\frac{1}{2}$ ounce. |
| | Water, | 2 gallons. |
| (c) | Boracic acid, | 2 ounces. |
| | Lime, | $\frac{1}{2}$ ounce. |
| | Water, | 2 gallons. |

These formulas were used in making solutions, which were applied to the same plants mentioned under No. 7. In no case

could any decided benefit which was due to the application be found nor were the plants particularly injured.

Neither borax nor boracic acid appear to possess any fungicidal value.

No. 9.—Iodine.—The use of this material for fungicidal purposes was suggested by a correspondent. Some of it was also sent us. A watery solution of the iodide of potassium was used for dissolving the iodine crystals, and this solution was so diluted with water that it resembled weak black tea in color. The proportions used were :

Iodine solution, 1 pint.
Water, 2 gallons.

All the plants to which this solution was applied were injured by it, the quinces probably more than any of the others. Fully 25 per cent. of the quince leaves were burned. This injury to the foliage obscured the fungicidal action of the iodine ; and although it was thought that some advantage had been gained from its use upon dewberries and quinces, still further trial is necessary to determine its value in this respect.

The application of dissolved iodine crystals is unsafe and it is of doubtful value.

No. 10.—Nitrate of soda.—This substance was suggested by Joseph Harris. It was applied in solution.

Soda nitrate, 2 ounces.
Water, 2 gallons.

Applications were made to the same plants mentioned under No. 7, but the variety of apple here used was the Baldwin. All the plants were injured. Fully 20 per cent. of the Baldwin leaves were affected, and 10 per cent. of the quince foliage. The other plants suffered but slightly. No reduction in the amount of fungous injury could be noticed following these applications.

Nitrate of soda when applied in water has a caustic action upon foliage and possesses apparently no fungicidal properties.

No. 11.—Caustic potash.—During the month of May, 1892, Mr. W. C. Archibald of Wolfsville, Nova Scotia, sprayed a large number of apple, peach and plum trees with a solution of "rock or caustic potash, diluted to about the proportion of 1 pound to 2 gallons of water." The buds on the trees had not yet burst although they were swollen. Regarding the result, Mr. Archibald writes : "By accurate observation my plums and apples,

where the potash was so used on the buds, are pronounced one-eighth larger than those borne in previous years."

As tested at this station during the past season, caustic potash was used in the form of sticks obtained from a druggist. It was used as follows :

Caustic potash, $\frac{1}{2}$ ounce.
Water, 2 gallons.

The potash dissolves readily in water and the solution was applied to the varieties of plants mentioned under No. 7. The application appeared to reduced the amount of leaf-spot on the quince about 30 per cent. and the dewberries were protected from about 25 per cent. of the injury visible an the check plants. The other plants which were sprayed showed no effects of the application. No foliage was injured.

Caustic potash may have some fungicidal value.

No. 11.—Pine products.—In April, 1892, we received from S. L. Goodale, of Saco, Maine, some abretic acid, and some kreolin, two substances derived from pines. As the amounts received were small the following formulas do not include so much of the materials as might be desired. Two ounces of kreolin were dissolved in one pint of water.

- (a) Abretic acid solution, 1 tablespoonful.
Water, 1 gallon.
- (b) Kreolin solution, 2 tablespoonfuls.
Water, 1 gallon.

None of the treated plants, these being the same as those mentioned under No. 7, showed any effects of the application. No foliage was injured, and fungi were as abundant as upon the check plants.

The application of pine products appeared to be without effect.

No. 12.—Antinonnin.—This substance is sold as an insecticide and was sent us by the manufacturers, Friedr. Beyer & Co., of Elberfeld, Germany. It is said that this compound was discovered by Prof. O. Harz and W. von Miller, of Munich, Germany. Antinonnin is a solid having about the same consistency as fresh cheese. It is bright golden-yellow in color, very easily soluble in water, and when dry is highly explosive. Consequently it must be kept in a moist place for if fire reaches it when once dry it will ignite almost as readily as gunpowder and it burns very much in the same manner. The station chemist has not yet

completed its analysis, but it is supposed to be an organic compound. It was used at the rate of

- (a) Antinonnin, $\frac{1}{4}$ ounce.
Water, 1 gallon.
- (b) Antinonnin, $\frac{1}{4}$ ounce.
Lime, $\frac{1}{4}$ ounce.
Water, 1 gallon.

The applications were made to Longfield apple trees, Champion quince, and to the same varieties of plants mentioned in addition under No. 7. After the first application it was immediately seen that the above formulas gave a too concentrated solution, so the same amount of the insecticide was used in two gallons of water. Even when thus diluted, formula (a) did considerable damage, destroying from 35 to 75 per cent. of the foliage to which it was applied; its use was discontinued. Six applications were made of the solution containing lime. This still possessed caustic properties, but the injury done was not serious. Apple and quince foliage suffered most, the injury amounting to perhaps 10 per cent. The other plants appeared to be unaffected.

The introducers of antinonnin claim that it is of value in destroying both leaf-eating and sucking insects. The quince tree to which the material was applied was badly infested with the common green plant louse. After the applications the number of insects was not visibly reduced. The poison would not adhere to their bodies but the drops rolled away and the insects were uninjured. Its effect upon chewing insects was not tested.

Antinonnin must be kept moist else it becomes a dangerous substance to handle.

Its action upon foliage when used alone is extremely caustic, and its solution must be applied weak.

Lime reduces the caustic action of this poison.

It possesses apparently no practical value as a destroyer of sucking insects.

SUMMARY.

1. Pumps used in spraying orchards must have a large capacity in order to be economical of labor. (Page 259.)
2. Automatic agitators have not given satisfactory results. (Page. 260)

3. That spraying may be facilitated, the trees in an orchard should be planted far enough apart to allow of the passage of a wagon when the orchard is in full bearing. (Page 260.)

4. The amount of liquid required to spray a full grown apple tree is about four gallons. (Page 261.)

5. The number of applications necessary to protect apples from the scab fungus cannot be definitely stated. As a rule, it may be said that a fungicide should be applied at least once before the trees blossom, and two applications are necessary after the falling of the blossoms, upon those varieties which are habitually injured by scab to any serious extent. Upon many susceptible varieties, one or two additional treatments are advisable. Only one or two applications may be applied with profit to resistant varieties. (Pages 267, 268.)

6. The advisability of making more than one or two applications of fungicide to Baldwin and Fallawater apples is doubtful. King, Maiden Blush, and Fall Pippin apples will repay, four and possibly six applications. Red Astrachan can also be profitably treated three times. (Page 269.)

7. Bordeaux mixture proved to be by far the most effective fungicide of those used. Following the Bordeaux in the order of their value are, the ammoniacal solution of copper carbonate, Paris green, fomite. (Page 270.)

8. No preference can be given Paris green or London purple in regard to their insecticidal value, provided they contain an equal amount of arsenic. (Page 274.)

9. Two applications of the arsenites are sufficient to control the ravages of the first brood of codlin moth larvæ. The financial gain derived from later application may be doubtful. (Page 274.)

10. The arsenites and the fungicides used in the apple orchard appear to be equally effective whether applied alone or in combination. (Page 274.)

11. Paris green and London purple, if applied more than once or twice to foliage, may do serious damage unless their caustic action is neutralized. (Page 274.)

12. Lime greatly reduced the caustic action of Paris green. (Page 275.)

13. The foliage of varieties of apples susceptible to the attacks

of apple scab was kept in a healthy condition by applications of fungicides. (Page 275.)

14. The size of Fall Pippin apples was practically doubled by protecting them from the attacks of the apple scab fungus. (Page 276.)

15. The use of fungicides may intensify the color of apples. (Pages 275, 276.)

16. The keeping qualities of Fall Pippin and Maiden Blush apples were apparently greatly augmented by the applications of Bordeaux mixture which were made to reduce injury from scab. (Page 277.)

17. The market value of sprayed apples was increased at least \$1.00 per barrel by the applications made during this season. (Page 278.)

18. Bordeaux mixture, when applied to peach trees alone, or in combination with London purple, did not injure the foliage. (Page 281.)

19. The ammoniacal carbonate of copper is very injurious to peach foliage, but the solution may be rendered less caustic by adding lime. The addition of Paris green can then also be made with comparative safety. (Page 281.)

20. Neither Paris green nor London purple should be used upon peach trees unless the mixtures are very dilute, or lime is added to neutralize the caustic action of the arsenites. (Page 281.)

21. Fostite gave only negative results when applied to peach foliage. (Page 281.)

22. The Bordeaux mixture, when properly applied, practically protects the foliage of apples, quinces, dewberries, raspberries, blackberries, and gooseberries from fungous attack. (Page 284.)

23. Copper chloride can be used as a fungicide to advantage when the solution is so strong that lime is required to neutralize its caustic action. On the whole, it is a promising fungicide. (Page 285.)

24. The experiences of the past season show no practical benefits arising from applications of iron chloride. (Page 286.)

25. Zinc chloride, as used the past season, cannot be applied with profit as a fungicide. (Page 286.)

26. Zinc sulphate has thus far proved of no practical value as a fungicide. (Page 287.)

27. Fostite contains about two per cent. of copper. (Page 287.)

28. Fostite possesses some fungicidal value, but its application to trees is difficult and its beneficial action so moderate that it cannot be generally recommended. (Pages 271, 288.)

29. Fostite has proved injurious to the foliage of apples, blackberries, dewberries, forcing cucumbers and forcing musk-melons. (Pages 288, 289, 290.)

30. When dry, fostite possesses no value as an insecticide which kills by contact. (Page 290.)

31. Neither borax, nor boracic acid and lime appear to possess any fungicidal value. (Page 291.)

32. The application to the foliage of dissolved iodine crystals is unsafe and of doubtful value. (Page 291.)

33. Nitrate of soda, when applied in water, has a caustic action upon foliage, and it possesses apparently no fungicidal properties. (Page 291.)

34. Caustic potash may have some fungicidal value. (Page 292.)

35. Abretic acid, and also kreolin, were applied for fungicidal purposes but no beneficial results followed their use. (Page 292.)

36. Antinonnin must be kept moist, else it becomes a dangerous substance to handle. (Page 292.)

37. The action of antinonnin upon foliage, when used alone, is extremely caustic, and the solution must be applied very dilute. (Page 293.)

38. Lime reduces the caustic action of antinonnin. (Page 293.)

39. Antinonnin possesses no practical value for destroying insects by contact. (Page 293.)

40. On the whole, therefore, I recommend that growers adhere to Bordeaux mixture in combatting fungi; or ammoniacal carbonate of copper may be used as a second choice, in case the Bordeaux cannot be applied with facility. Paris green and London purple are still the best general insecticides; and the greater value seems, in general, to reside in the Paris green.

E. G. LODEMAN.

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ALL DIVISIONS.

SUNDRY

Investigations of the Year.



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50. The Bud Moth.
51. Four New Types of Fruits.
52. Cost of Milk Production.—Variation in Individual Cows.
53. Œdema of the Tomato.
54. Dehorning.
55. Greenhouse Notes.
56. The Production of Manure.
57. Raspberries and Blackberries.
58. Four-Lined Leaf-Bug.
59. Does Mulching Retard the Maturity of Fruits?
60. The Spraying of Orchards.
61. Sundry Investigations of the Year.

BOTANICAL DIVISION.

CRYPTOGAMIC BOTANY AND PLANT PATHOLOGY.

ŒDEMA OF APPLE TREES.

During the month of July specimens of diseased apple twigs were received from Mr. E. A. Crow, of New York City. The soft outer tissue of the limbs was in a state of decay and occupied by a fungus, some species of *Fusarium*, which resembled *F. arcuatum* B. & C., which was described from the bark of *Pirus malus* in South Carolina. Mr. Crow had supposed this fungus to be the cause of the trouble and had tried the use of the Bordeaux mixture after having scraped off the bark from the diseased places. Since so many of the species of the genus *Fusarium* grow only in tissues which have been injured by some other agent and all of the material which was first received was in such an advanced state of decay, I requested Mr. Crow to send me some fresh specimens which would represent the entire progress of the trouble from its inception. From this material which was received in good condition the external peculiarities of the disease may be described as follows :

Minute elevations appear on the surface of the branches or trunks which gradually increase in size from one-eighth to one-fourth of an inch long and nearly as wide. They are usually quite close together and frequently by increase in size become confluent when a large number extend over quite a large surface and appear as one of very irregular form. These elevations present the appearance of blisters and they are well shown in figure I, which is from a photograph of three of the specimens received. Two of them show the appearance of the twigs when the blisters are most prominent, while one of them shows the collapsed condition of the tissues which always results after the tissues are broken down from decay.

Microscopic sections through the parts of the twigs where the

trouble is recent shows that no fungus is present, and in fact there is no ground for the causal connection of any parasitic organism. Immediately beneath the periderm the young phellogen tissue at the points of the blisters is seen to be very greatly elongated radially. This radial elongation of the phellogen causes the periderm to be raised in the form of a blister. Beside the radial elongation of the phellogen cells they are also very much distended. This distension continues until the cell walls are no longer able to stretch because they become so thin that they break and the cells collapse. This collapse of the phellogen cells causes the collapse of the blisters and in drying these affected areas are depressed below the normal surface of the twig. Also the dying tissue forms a nidus for such saprophytic fungi as the *Fusarium* which was in many cases present. This dropsical swelling of the tissues is of the same nature as that which occurs sometimes with tomatoes when grown under conditions which favor rapid and continuous root absorption and at the same time hinder transpiration, or growth. A thorough study of this trouble with the tomato was made last winter by the author and published in Bulletin No. 53, May, 1893, of the Cornell Station. To this the reader is referred for a full discussion of the unequal operation of the physiological laws which induce the trouble, and for the bibliography.

In the case of the tomato oedema the unequal operation of the physiological laws was due to certain unfavorable conditions of greenhouse lighting and heating. This would not apply to the case of the apple trees which were grown out doors. But since the trouble was like in kind the cause would probably be found in some condition of soil, cultivation, or pruning of the trees, which would favor root absorption and hinder transpiration, or growth at a sufficient number of points on the tree to take charge of all the water which the roots absorbed. Inquiry of the owner developed the fact that the soil in the young orchard was very fertile and well worked, and that the conditions so far as soil was concerned were very favorable for rapid root absorption and growth. In fact the trees grew very luxuriantly and were the marvel of the neighborhood. But during the winter and early spring they were very severely pruned. According to the owner



FIG. 1.—*Edema of Apple Trees.*



FIG. 3.—*Melanconium fuligineum*.

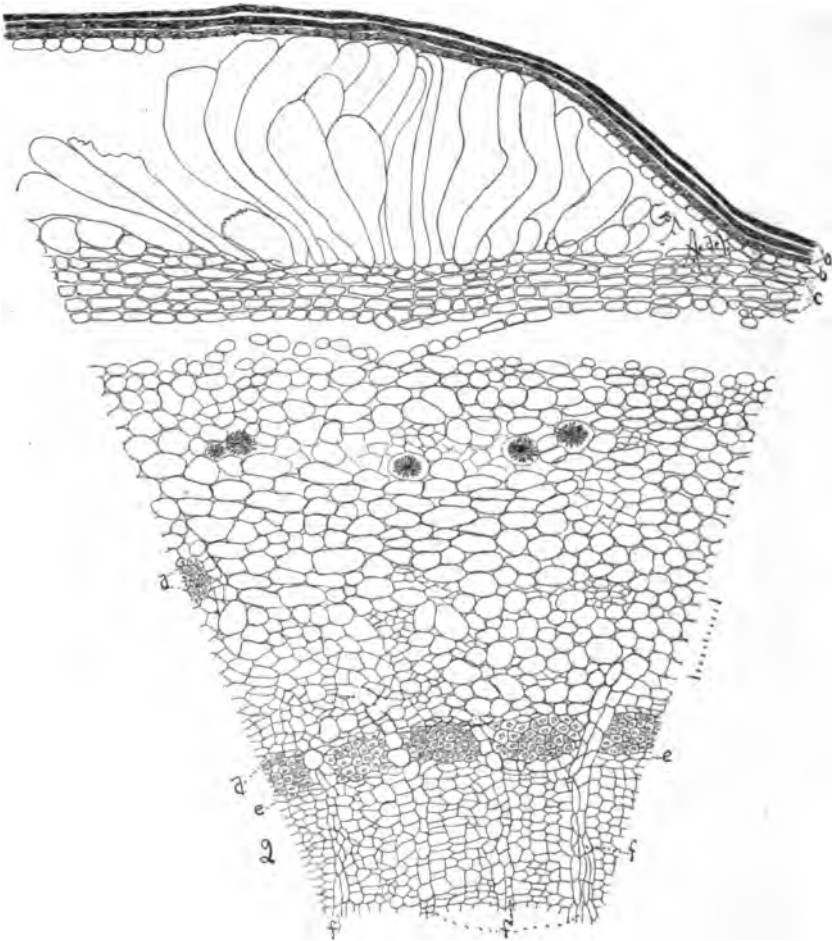


FIG. 2.—*Edema of Apple Trees.*

they were pruned very close, leaving only the main limbs and twigs and a few secondaries, and the new growth was cut back one-third. This left but few growing points. When root absorption and growth began in the spring, there being no leaves to discharge the excess of water through transpiration, the few growing points could not dispose of the excess. Consequently the thin walled phellogen tissue could not stand the strain. Figure 2 represents a portion of a cross section of one of the blisters;

a, periderm; *b*, phellogen; *c*, inner layer of cells developed from phellogen; *d*, bast fibers; *e*, cambium; *f*, medullary rays. Scale = 1 mm.; object magnified 10 times more than the scale. Drawn with aid of camera lucida.

The cause being known the remedy would be suggested to all, that too vigorous growth should be guarded against and too severe pruning should not be indulged in.

GEO. F. ATKINSON.

ARTIFICIAL CULTURES OF MELANCONIUM FULIGINEUM.

The suggestion made by Miss Southworth* that the *Melanconium fuligineum* (Scrib. et. Viala) Cav., should be placed in the same genus with the Ripe Rot of grapes and apples (*Gloeosporium fructigineum*, Berk.) led me to make artificial cultures of the fungus for the sake of comparison with cultures of the genus *Gloeosporium* of the same type as the *fructigenum*. Material was obtained from Mr. F. S. Earle of Ocean Springs, Miss., who was kind enough to take the trouble to collect some fallen grapes during the month of February, 1893, from a vineyard which had been affected with the fungus the previous season. A few of these grapes possessed numerous pustules characteristic of *Melanconium fuligineum* and which were filled with spores. With these dilution cultures were started in Petrie dishes using ordinary nutrient agar.

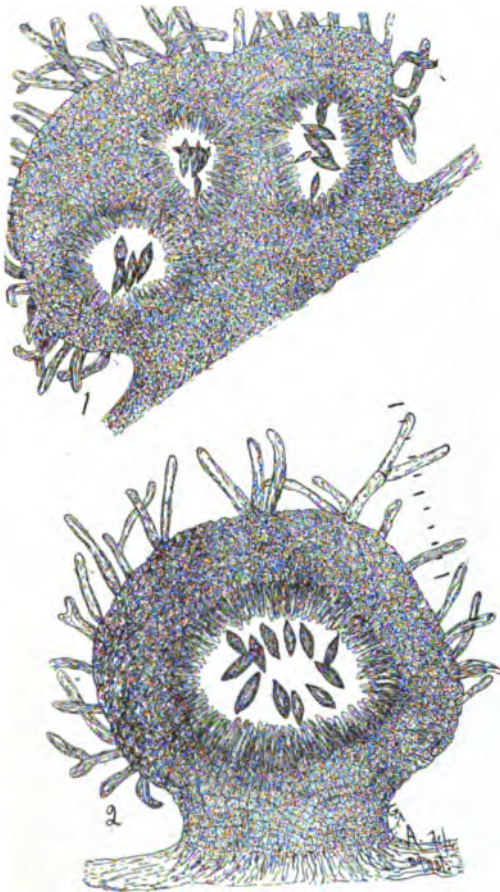
In 24 hours the spores were germinating. One to several germ tubes may arise from the spore, usually several. The spores remain continuous, and at first the threads develop septa scantily or indistinctly. The hyphae soon branch and usually profusely quite close to the spore, so that a rudimentary stroma appears to be developed quite near the center of growth. The spores germinate quite readily in the nutrient agar and growth continues readily for a few days, but no spores were developed in the plate cultures even after a period of three weeks. Even after the first few days the fungus no longer grew vigorously. The nutrient

*Journal Mycology, Vol. VI. No. 4, 1891, p. 171.

agar did not supply the needed kind of nourishment for it, or lacked favorable physical properties.

A few of the colonies of the threads known to have originated from spores of the *Melanconium fuligineum* were transplanted to culture tubes of nutrient agar, but in a month's

time seemed to make no growth or but very little. At the same time several colonies were transplanted to sterilized bean stems in culture tubes. This medium proved to be very favorable for the organism, for in a few days a profuse growth appeared at the point of the transplantings. The threads of the fungus grew both within the tissues and upon the surface of the stems. In macroscopic appearance the surface growth first formed a scant downy, whitish web with a number of ascending and procumbent threads at the advancing edge of the web. From the center of growth this was soon succeeded by a darkening of the fun-



FIGS. 1 AND 2.—*Melanconium fuligineum*.

gus, brought about chiefly by the discoloration of the threads lying close to the substratum, and the appearance of stroma or stools scattered over the surface which gave the stem a punctiform

appearance. This growth spread until the entire surface of the stems so far as the moisture extended presented a blackened or charred aspect, studded with numerous black points. The fungus also grows out upon and in the infusion in which the stems are partly immersed, and in time forms a thick web.

The elevated stools when magnified simulate in form a pezizoid stroma, being attached to the substratum by a very short stem, and presenting a plane or convex surface, their perpendicular diameter being less than their horizontal diameter. These stools perform the same function in the artificial cultures that the pustules on the berries do, and produce myriads of fuliginous navicular spores. The superficial position of the fruiting stroma is probably due to the difference in the substratum. Sometimes the spores are borne upon the surface of the dark stroma, or very frequently the stroma forms a pseudo-pycnidium covered with loose threads some of which bear spores, but the center is occupied by a hymenium from which numerous basidia converge toward the center of the cavity and bear multitudes of the characteristic spores, as shown in figures 1 and 2. When the stroma attains some size there may be several cavities at different relative depths.

When the cultures in the Petrie dishes were about one month old the plates were photographed and plate No. 3 is reproduced in figure 3. Since this was a dilution culture for the separation of the fungus the culture is a mixed one and other colonies than those of the *Melanconium fuligineum* appear in the plate. Up to this time in the agar the colonies remain colorless. The growth in dilution culture No. 3 where the fungus had more room did not exceed 1 cm. in diameter, and while the growth was quite compact, radiating threads are shown on the margin of the colony. In the photograph the colonies of *Melanconium fuligineum* are those of the medium size and the places from which the transplantings were made can be readily seen. In the illustration beside the *Melanconium* are common moulds, bacteria, and a dark yeast form which produces deep black points in the medium.

Compared with cultures of the type of *Gloeosporium fructigenum* which has fallen into my hands, the *Melanconium fuligineum* seems to be generically distinct as shown by the characters of germination, the growth in the agar plate, and the characters of

fructification on a more solid artificial substratum like sterilized bean stems. A full comparison it does not now seem best to make, reserving it for the study of the *Gloeosporiums* which are now in progress. Figures 1 and 2 drawn with aid of camera lucida; scale=1mm.; object magnified 30 times more than scale.

GEO. F. ATKINSON.

POWDERY MILDEW OF CRUCIFERS.

A powdery mildew of certain cultivated cruciferous plants is probably of common occurrence in America, but thus far it does not seem to have attracted much attention. This may be because it is not very injurious. At present this mildew is known only in the conidial stage, on crucifers, and I do not remember ever seeing any reference to its occurrence on these plants in the United States. It frequently becomes very injurious to turnips in England where it has been known for some time. W. G. Smith records it in his little book, "Diseases of Field and Garden Crops" under the name of *Oidium balsamii*, Mont.

Oidium is a form genus which includes several species that are known to be the conidial stages of some pyrenomycetous fungus especially of the group *Erysipheæ*. According to Saccardo several of the microsporous species are probably more properly referable to the genera *Ovularia* and *Ramularia*.* Several of the larger species of *Oidium* have already been correlated with their ascosporous form.

Oidium balsamii, Mont. was named from specimens of the mildew on *Verbascum montanum* collected at Milan by Balsamo and referred by him to *Oidium tuckeri*. Berkeley† first published the species using Montagne's manuscript name, and recorded its occurrence in England on *Verbascum nigrum*, and also to this species referred the mildew which was at one time abundant and injurious upon the Culhill's Black Prince Strawberry in the Kew Gardens.‡ In 1880 it appeared in abundance in England on tur-

* See Syll. Fung. Vol IV, p. 41.

† Ann. Nat. Hist., Vol. XIII. 1854, p. 463.

‡ Gard. Chron. Apr. 15th, 1854, p. 263.

nips* for the first time though it had been observed there before that time.

During the autumn of 1893 the present writer observed it on turnips, Japanese cabbage and Scotch green curled kale at Ithaca, N. Y., and in the autumn of 1889 at Auburn, Ala., upon ruta bagas.

The turnips did not seem to be very much injured though in several cases large areas of the surface of the leaves were white with the mildew. In many cases the Scotch kale leaves were completely covered on both surfaces with the growth, and in such cases must produce considerable injury. The Japanese cabbage which was affected was going to "seed," and not only were the leaves affected but several of the fruiting stems were completely covered by the fungus. Several *Erysiphe* which fruit shyly on the leaves of their hosts frequently do so abundantly on the stems and it was hoped that in this case the perfect form of this *Oidium* might be obtained, but thus far no sign of the ascosporous stage has been seen. It would be difficult to properly correlate the form without the evidence to be derived from this stage, but there is some evidence to be gained which at least suggests relationship to some species. As I have found, the haustoria on the mycelium are lobed. It is quite possible that the form is ultimately to be referred to some of the species of the genus *Erysiphe*. As DeBary† has pointed out the haustoria on the mycelium of *Erysiphe galeopsidis* are lobed and this character is useful in differentiating this species from *Erysiphe cichoracearum*. No species of *Erysipheæ* have as yet been recorded upon any of the cruciferous family. If the *Oidium* on turnips has been properly referred to the *Oidium balsamii* on *Verbascum* then there would be some probability at least that this was the conidial stage of *Erysiphe galeopsidis*, since that species has been found upon a genus of the *Scrophulariaceæ* (*Chelone*). In size and form the Conidia of *Erysiphe galeopsidis* agree very well with those of the turnip mildew. But this evidence can only suggest, not determine, the true relationship.

GEO. F. ATKINSON.

* Gard. Chron. XIV, 1880, p. 392.

†Morp. und Phys. d. Pilze, III p. 49.

AGRICULTURAL DIVISION.

WHEAT CULTURE BY THE JETHRO TULL OR LOIS-WEEDON SYSTEM.

Since to the investigations and practices of Jethro Tull is due more than to any other cause the superior culture given to roots and grain crops in England, it may not be out of place to state briefly the chief points of his system.

Jethro Tull, an English landlord educated for the bar, visited Italy and the South of France at the close of the sixteenth century in order to regain his health. In these countries he learned that many successive crops were taken from the land without any apparent diminution of yield. He says, "Vines kept in the condition of low shrubs are constantly plowed (cultivated) in the proper season; these have no other assistants, but by hoeing, because their heads and roots are so near together that dung would spoil the taste of wine they produced, in hot countries."

From what he had seen and learned during his visits he conceived the following propositions:

1. "That interculture among the growing crops is a necessary preparation in well conducted farming."
2. "That adequate tillage is not only an economic substitute for manure, but"
3. "Thorough tillage is also competent, with or without the aid of manure, to secure the profitable growth of any given species of cultivated plants, year after year, in succession." He began to raise wheat much as we raise corn, in drills, with intervals wide enough for the passage of the horse hoe. The rows of each succeeding crop of wheat were planted in what had been intervals the year before.

Up to the time of his death, in 1741, he had grown thirteen unmanured wheat crops without intermission, and without decrease, in the same ground. In the latter years of his practice he frequently grew a hundred acres of wheat in one season by his improved method of horse hoeing.

Rev. Samuel Smith adopted Tull's plan with some improvements and modifications at Lois-Weedon, Northamptonshire. He was extremely successful and hence the system of horse hoe culture for wheat and other similar grains is often known as the Lois-Weedon system.

Smith succeeded in growing twelve successive crops of wheat without the application to the soil of any manure whatsoever, and he claimed that no degeneration or diminution of quality ensued. Many experiments similar to those conducted by Smith and Tull have been carried on in the United States always with satisfactory results so far as the yield was concerned, but with high priced labor, and cheap virgin soil it has been found in most cases unprofitable to practice, in any large way, the Lois-Weedon system of wheat culture in its entirety.

LOIS-WEEDON SYSTEM OF AGRICULTURE MODIFIED.

The experiments were begun in 1874. The previous year the land had raised a crop of oats, without manure, and in 1872 and for several years previous to that date had been in blue grass pasture.

The land after removing the oat crop of 1873 was in a bad lumpy condition. It was summer fallowed in 1874 and not manured. The plots were $20\frac{2}{3}$ rods long and the entire area was cut into 8 strips of $\frac{172}{1000}$ of an acre, each strip being $5\frac{1}{2}$ feet wide.

The first year of the experiment every other strip was drilled to wheat, and the intervals cultivated, the following year the treatment was alternated; the ones having borne a crop of wheat the previous year being under summer fallow. Clawson seed wheat at the rate of two bushels per acre was used in all cases.

Yield 1st year, 1874-5, season poor, 158 lbs., at the rate of 10 31 bu. per acre.

"	2d	"	1875-6,	"	fair,	369	"	"	"	35.77	"	"
"	3d	"	1876-7,	"	sup'r,	694	"	"	"	67.23	"	"
"	4th	"	1877-8,	"	fair,	637	"	"	"	61.42	"	"

It should be noted that the strips are very narrow, only one width of the drill being used, the intermediate spaces between these drilled plots were cultivated four or five times each season.

The effect of using such narrow plots was to allow the wheat

to virtually occupy the whole land, as the culture between these narrow plots was by the common single one-horse cultivator, this permitted the roots to extend and feed upon the plots which were left vacant. At harvest time the whole area had the appearance of a continuous field of wheat, as the heavy heads leaned over into the spaces, and shaded and covered the whole ground. Note that these experiments were conducted somewhat differently from those which are reported below.

No manure or fertilizers of any kind were used during the four years of the experiment. If it is allowed that the wheat occupied all the ground, the yield would be just half as much per acre as is stated above. Even then the yield was large considering the quality of the land. Each year as the experiments went on the land became more friable and in better condition physically than it was at the beginning. The wheat was removed from the field as soon as it was cut, and the ground plowed the same or the following day. This gave the plots which had produced the wheat, a short summer fallow from the middle of July until fall, the same year; a summer fallow from the last of May to the first of September the following year. This, as it will be seen, was really "maneuvering" the land, thus causing it to increase in production by culture.

In 1888 a system of experiments similar to those recorded above, with additional plots treated with fertilizers and farm manures were begun.

These plots were located in the same field, but not on the same ground used in the preceding experiments, upon ground where for some seven or eight years experiments had been going on in the cultivation of Indian corn. The plots of Indian corn were narrow and laid lengthwise of the field so when the field was laid off for conducting the experiments in wheat it was seen to be best to lay the plots cross ways of the corn plots, because there had been variable and different treatments in the cultivation of the corn. Some plots had received nothing, others liberal applications of fertilizers. By laying out the plots at right angles to the old ones it at least made them all alike, though one portion of the plot might be quite different in fertility from another portion. The plots contained $\frac{1}{10}$ of an acre each, and were separated by

strips of grass $3\frac{1}{2}$ feet wide. Later the grass was plowed up and the unoccupied strips were kept clean throughout the summer by frequent cultivations.

The primary object of the experiment was to show the value of superior culture on rather poor clay land, such as is frequently found in the wheat districts of New York, and to determine if possible how much of the plant food of the land can be secured profitably without adding any fertilizers. The fitting of the land for most crops is done so badly that it was thought best to not only emphasize the value of culture but to discover if in some part at least, culture might be substituted for expensive commercial fertilizers.

These being the chief objects of the investigation, it will be necessary to speak but briefly of the manured and fertilized plots.

The manured plot received the first year two tons and in all subsequent years one and one-half tons of mixed horse, cow and sheep manure which had been kept in a covered yard during the winter and until the last of May, when it was removed to a rotting pit in the open field from whence it was taken in September to the plots and spread on the surface of the plowed ground. The manure contained a high per cent. of nitrogen owing to the liberal use of cotton-seed meal in feeding the animals. After the first year the wheat had a tendency to lodge, which tendency became so bad in the last year of the experiments that in the Fall of 1892 no manure was used. On plot 3, 60 lbs. of Bradley's superphosphate were drilled in with the seed in the first three years, in the fourth, 60 lbs. of Small's superphosphate, and in the fifth, 15 lbs. of double superphosphate, 15 lbs. of sulphate of potash and 10 lbs. of sodium nitrate. Briefly stated it may be said that the plot received annually 45 lbs. of phosphoric acid, 15 lbs. of potash, and 15 lbs. of nitrogen per acre.

Plot 4 which was in wheat without any "rest" by means of a summer fallow was plowed, as were all the plots immediately after harvests, harrowed, rolled and cultivated several times making indeed a short summer fallow.

All plots contained $\frac{1}{16}$ of an acre each. Two plots were used in the Tull or summer fallow system, so a crop was harvested on each every other year, while in all other cases a crop was harvested every year.

I. Summer fallowed.				II. Farm yard manure.		
Year.	Tall system modified.		Bushels per acre.	Wheat. Lbs.	Straw and chaff. Lbs.	Bushels per acre.
	Wheat. Lbs.	Straw and chaff. Lbs.				
1889.....	213	397	35.35	218	372	36.33
1890.....	208	553	34.66	176.5	552.5	29.41
1891.....	213.5	856.5	35.58	159	719	26.5
1892.....	132.5		22.08	103		17.16
1893.....	175.3	274.7	29.21	82.2	187.8	13.7
Totals.....	942.3	2063.2		738.7	1831.3	
Average..	188.46	515.8	31.41	147.76	457.8	24.62

III. Fertilizer.				IV. Nothing.		
Year.	Wheat. Lbs.	Straw and chaff. Lbs.	Bushels per acre.	Wheat. Lbs.	Straw and chaff. Lbs.	Bushels per acre.
1889	193	367	32.16	196	374	32.66
1890	194	446	32.33	215	533	35.83
1891.....	123	207	20.5	139	246	33.16
1892	121.5		20.25	139		32.16
1893.....	88.9	201.1	14.81	79.8	108.2	13.3
Totals. ...	720.4	1221		768.8	1261.2	
Average..	145.08	305.3	29.01	153.76	315.3	30.75

CONCLUSION.

From these and many other similar experiments conducted in Europe, it is believed that on strong or clayey lands it is often more economical to secure available plant food by culture than by the purchase of fertility.

That in strong wheat soils there is more plant food than the variety of wheat grown can utilize, though enough may not be available to produce a maximum crop.

That in our changeable climate the wheat plant is so handi-

capped at times for want of suitable climatic conditions, that it is unable to appropriate much of the available plant food in the soil and hence is often not benefited by additional nourishment.

That the plants were unable to elaborate more food than the amount furnished by the soil under the superior culture.

That under certain conditions even a moderate amount of manure or fertilizers may not only fail to increase the yield but may be postively injurious to the crop to which they are applied.

I. P. ROBERTS.

CORN—DETASSELING.

July 14, 1893, three plots were marked out in the University corn fields for experiments in detasseling. Plots I and II were side by side in a field of well drained gravelly loam and the corn early and uniformly good. Plot III was on a clay knoll in a field of late corn that suffered severely from the drouth during the latter part of the season. All plots were surrounded by corn that had not been detasseled. Plots I and II contained 16 rows each and plot III 9 rows; each row contained 15 hills. In plots I and III the tassels were removed from alternate rows, while in plot II every fourth row was left with tassels on, that is the tassels were removed from the first three rows, left on the fourth, removed from the next three and left on the eighth row and so on throughout the remaining rows of the plot.

The tassels were removed by hand by pulling them out as soon as they appeared. This operation was performed quite rapidly as comparatively little force was necessary to cause the stalk to break just above the upper joint and without any injury to the leaves whatever, if done before the tassels had become fully expanded. From the experiments in detasseling made at the station it is thought to be of prime importance to completely remove the tassel before it has expanded and commenced to shed pollen. As the tassel at this time is partially protected, within the folds of the leaves, it can only be completely removed by grasping the top of the tassel and giving it an upward pull which causes it to break off as described above. Experiments in detasseling have been made at other experiment stations where the practice has been to

remove the tassels by cutting them off with a corn knife which would either cause an injury to the leaves or a delay until the tassels had become fully expanded and had shed pollen, as some tassels will shed pollen while yet partially protected within the folds of the leaves. In either case a benefit ought not to be expected from the practice. Our experiments show that the object of removing the tassels is not accomplished if they are allowed to remain until fully expanded and become polleniferous.

The following tables give the results of the practice from each of the three plots :

PLOT I.

Row.	Tassels.	No. of stalks.	No. of abortive ears.	No. of good ears.	No. of poor ears.	Wt. of good ears.	Wt. of poor ears.	Wt. of stalks.
1	off	65	20	40	23	17.5	5.5	36
2	on	61	13	36	14	14.5	4	35
3	off	67	16	29	31	13	7.5	38
4	on	63	20	26	18	13	5	40
5	off	72	27	30	29	14	7.5	38
6	on	80	21	28	23	13.5	6	41
7	off	65	17	28	28	13	6	32.5
8	on	73	22	25	26	10.5	6.5	38.5
9	off	70	17	39	12	17	3	34
10	on	69	18	36	16	16	4.5	38
11	off	67	19	32	29	15	7	33
12	on	66	19	38	17	18	4	39
13	off	68	25	30	28	14	7	40
14	on	66	17	29	17	12.5	4	35
15	off	63	21	30	23	13.5	7.5	38.5
16	on	82	18	30	27	12	5.5	40
Total off.....		537	162	258	203	117	51.	290
Total on		560	148	248	158	110	39.5	306.5
Average off.....		67.1	20.2	32.2	25.4	14.6	6.3	36.25
Average on.....		70.	18.5	31.	19.75	12.7	4.9	38.31

Yield per acre, tassels off, 5000 lbs

Yield per acre, tassels on, 4449 lbs.

Gain by removing tassels, 12.4 per cent.

PLOT II.

Row.	Tassels	No of Stalks.	No of abortive ears.	No. of good ears.	No. of poor ears.	Wt. of good ears.	Wt. of poor ears.	Wt. of stalks.
1	off	66	25	27	31	12.5	8	39
2	off	61	22	39	17	17.5	5	37.5
3	off	72	18	43	23	18	6.5	39.5
4	on	71	14	34	18	14	4	35
5	off	62	17	36	18	17.5	4.5	35
6	off	66	18	45	20	20.5	5.5	40
7	off	69	20	33	30	14.5	6.5	39
8	on	72	19	30	26	12	5	33
9	off	73	25	31	31	13	8	41
10	off	75	20	34	33	15	8	46.5
11	off	74	29	36	32	15.5	7	45.5
12	on	60	22	28	19	12.5	4	39.5
13	off	64	20	35	25	15.5	6.5	42
14	off	60	21	37	20	16.5	5	37
15	off	69	23	29	31	13	8.5	42
16	on	61	10	28	24	12.5	4.5	40
Total	off	811	258	425	311	189	79	484
"	on	264	65	120	87	51	17.5	147.5
Average.....	off	67.6	21.5	35.4	25.7	15.7	6.6	40.3
"	on	66	16.2	30	21.75	12.7	4.4	37.4

Yield per acre tassels off, 5316 lbs.

" " " " on, 4077 lbs.

Gain by removing tassels, 30.3 per cent.

From the accompanying tables it will be seen that in each plot there was a greater yield of corn from the detasseled rows than from the rows where the tassels were left on. Not only from the total yield of corn but also a gain in the weight of both the good and poor ears. From each plot the weight of good ears from detasseled rows was greater than the weight of good ears from the rows with tassels; the same is true concerning the poor ears from each plot. The average weight of the ears from rows with the tassels on, correspond very nearly with the weight of the ears from detasseled rows, showing that the increased yield is from a greater number of ears rather than larger ears. There is also shown a tendency toward greater ear production on the detasseled rows by the increased number of abortive ears. All "sets" bearing silk but without grain were classed as abortive ears.

PLOT III.

Row.	Tassels.	No. of stalks.	No. of abortive ears.	No. of good ears.	No. of poor ears.	Wt. of good ears.	Wt. of poor ears.	Wt. of stalks.
1	on	64	7	19	24	6	4	25
2	off	57	21	21	29	6	4.5	25
3	on	61	25	15	25	3	4.5	23.5
4	off	60	14	19	24	5.5	4	25
5	on	54	19	16	25	5.5	4.5	25
6	off	70	15	21	36	7	5	26
7	on	63	21	15	32	4	3.5	24
8	off	67	21	28	28	7.5	3.5	27.5
9	on	74	17	28	26	7.5	3	33
Total.....	on	316	89	93	132	28.	19.5	130
"	off	254	71	89	117	26	17	103.5
Average.....	on	63.2	17.8	18.6	26.4	5.6	3.9	26
"	off	63.6	17.9	22.25	29.25	6.5	4.25	25.87

Yield per acre tassels off, 2559 lbs.

" " " " on, 2262 lbs.

Gain by removing tassels, 13 per cent.

The report of a recent experiment in detasseling is published in Bulletin 25 of the Nebraska Experiment Station where the tassels were removed by the use of a *corn knife*, and the results are summed up in the following conclusions :

1. "The detasseling of corn seems to be a positive detriment and loss, as shown by the results in two years' trial. This is not conclusive evidence, but strongly indicative of what we may expect from the practice.

2. The expense is about \$1.25 per acre and would require an increased yield from three to five bushels of corn to pay for the labor involved, this depending on the price of corn in any given locality.

3. Although the results of the experiment in 1892 are so strongly contrasted and so widely divergent, yet we do not deem them decisive. We propose to repeat the experiment on still larger areas and with different varieties of corn and note the results before we announce the positive rule that 'detasseling does not pay.'"

Although not conclusive the experiments made at this Station indicate that there is more pollen produced by the corn plant than is necessary to produce a maximum crop and that this over production is an exhaustive process.

The following are the results in brief of detasseling practiced at this Station for four years :

In 1890 a gain in total yield of corn of 50.6 per cent.

" 1891 a very slight gain.

" 1892 a gain in total yield of corn of 21 per cent.

" 1893 a gain in total yield of corn of 19.3 per cent.

GEO. C. WATSON.

ENTOMOLOGICAL DEPARTMENT.

THE PEAR LEAF BLISTER.

Phytoptus pyri.

Order ACARINA ; family PHYTOPTIDAE.

Reddish blister-like spots an eighth of an inch or more in diameter appearing on pear leaves in the spring and changing to black corky spots in July, each with a minute opening in it.

In Bulletin 23 of this Station, issued in December, 1890, this disease of pear leaves was discussed at some length. It was then realized that the only methods of checking the disease which could be suggested were too laborious to be practicable except where the trees were young or few in number. This need of a cheaper and easier method of fighting this pest has been the subject for experimentation during the last two years. Some of these experiments have been strikingly successful, and we are now confident that this disease, which is alarmingly on the increase in the United States and Canada, can be easily and cheaply controlled.

As the disease has been studied during an entire season, other phases of it, not before recorded, have been seen. The disease has also appeared in several other localities and is causing considerable alarm among pear growers, judging from the reports of correspondents. It is the purpose of this article then to record these new facts, and to tell pear growers how the pest can be easily and cheaply combated. As Bulletin 23 is now out of print, it has also seemed best to again discuss the disease in detail.

Symptoms of the disease.—The disease appears on the pear leaves, before they are fully expanded from the bud in the spring, in the form of red blister-like spots an eighth of an inch or more in diameter. During this red stage of the disease, the spots are more conspicuous on the upper surface of the leaves. About June 1, the spots gradually change to a green color hardly dis-



FIG. 1.—Cluster of infested leaves representing the disease in its brown stage, as seen from below on three leaves and from above on one leaf. (From a photograph of leaves collected in August. Natural size.)

tinguishable from the unaffected portions of the leaf; this change takes place on the lower side of the leaf first, and the spots may thus be red above and green below. In this green stage, which seems to have been heretofore overlooked, the badly diseased leaves present a slightly thicker corky appearance; otherwise the disease is not readily apparent especially where not severe. This green stage lasts about a week or ten days; and about June 15 the spots may be found changing to a dark brown color beginning on the lower side of the leaf. The tissue of the diseased parts or spots then present a dead, dry, brown or black, corky appearance. The spots are also more conspicuous on the lower side (Fig. 1), and remain unchanged until the leaves fall in the autumn. They occur either singly scattered over the surface of the leaves or often coalesce forming large blotches which sometimes involve



FIG. 2.—Part of an infested leaf, seen from below, showing several of the galls considerably enlarged. (From a photograph.)

a large portion of the leaf (Fig. 1). The disease often appears on the young leaves of the new growth during the summer. The spots are then also first red and pass through the green stage to the brown. No variety of pears seems to be exempt from the attacks of the disease. The disease is not known to attack anything but the pear in this country.*

This Pear Leaf Blister is sometimes mistaken for a common fungus disease, the Pear Scab, which attacks the pear, also forming blackish spots on the surface of the leaves which have a slight resemblance to the blisters. The fungus, however, does not pro-

* Mr. Crawford records the finding of similar diseased spots on a fern (a *Gleichenia*) growing among infested pear trees in Australia. Although the inhabitants of the spots differed in color from those on the pear, he believed this to be due to the difference of the food and concluded that the disease was the same on the fern and pear.

duce the blister-like corky appearance; nor is there scarcely any thickening of the leaf where it is attacked by the fungus.

These diseased portions of the leaf are termed galls, as are the various abnormal vegetable growths produced by true insects. Figure 2 represents several of these galls, or blisters as they are sometimes called by fruit growers; the galls are magnified about six diameters and well illustrate their blister-like corky appearance.

In figure 3 is shown a section of a pear leaf through one of the galls, made doubtless while the gall was in its red stage. Here the leaf is seen to be greatly thickened at the diseased part. And in addition to the swelling of both



FIG. 3.—Section of a leaf; g, gall in its red stage; n, n, normal structure of the leaf; o, opening of the gall; e, eggs. (After Sorauer.)

surfaces of the leaf, its internal structure is seen to be modified. In some parts there is a multiplication of the tissue cells, and in others a large part of the cells have been destroyed.

As the season advances and the galls become dry and brown, the thickening of the leaf becomes less marked, especially on the upper surface. Figure 4 represents a section of a leaf collected and studied in October. Here the tissues in the diseased spot are dead, and there has been a shrinkage of the affected parts until the gall is but slightly thicker than the uninjured portion of the leaf.

If these galls be examined from the lower side of the leaf with a hand lens (an instrument which every fruit grower should own) there can be seen near the center of each a minute round hole. It can be discerned in some of the galls represented in figure 2. This hole leads into a cavity within the substance of the leaf (Figs. 3 and 4, o) and in this cavity reside the creatures that cause the disease.

Appearance of the Inhabitants of the Galls.—The minute creatures that attack the tissues of the pear leaf in such a manner as to cause the abnormal growths—the galls—which form their homes, are what are popularly known as mites. They are exceedingly small, being practically invisible to the unaided eye; and even

with a good hand lens they appear as minute whitish specks. In fact, the best of microscopes is necessary in order to study their structure satisfactorily. So small are they that it would take 150 of them placed end to end, and 600 placed side by side to meas-

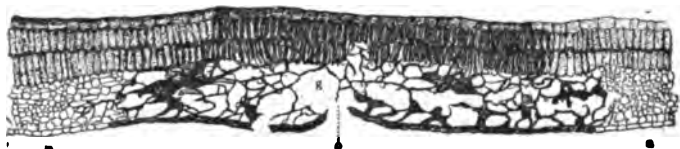


FIG. 4.--Section of leaf showing structure of gall in autumn; g, gall; n, uninjured part of leaf; o, opening of gall.

ure an inch. They are usually whitish in color, sometimes with a slight red or brown tinge. The body is cylindrical in form, tapering slightly towards each end (Fig. 5). It is ringed throughout the greater part of its length with about one hundred very fine rings. Its four legs are placed near the head end of its body, so that when the mite walks it drags its body after it. The head is in the form of a conical snout, within which are two sword-like jaws. The body and legs are furnished with a few hairs which are constant in number and position.

Classification of the Pest.—The cause of this Pear Leaf Blister is not a true insect, but a mite. (The mites are more closely allied

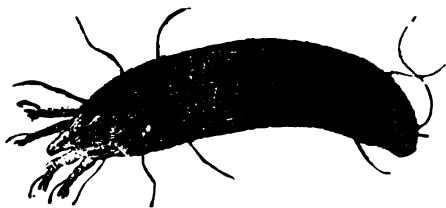


FIG. 5.—The adult mite, greatly magnified.

to the Spiders and Scorpions than to the true insects). The southern Cattle-tick, the Itch-mite, and the Red Spider are well-known members of the same order (*Acarina*) of animals to which this

pear pest belongs. As a rule, newly-hatched mites have three pairs of legs, and a fourth pair is added during growth. The members of the genus *Phytoptus*, to which this pear pest belongs, differ, however, from all other mites in that they never possess but two pairs of legs.*

*These curious four-legged mites seem to have been first observed in 1834. For 17 years they were thought to be immature forms of some eight-legged

The popular name for this pear pest that has come into general use is the Pear Leaf Blister Mite. Crawford called it the Pear Phytoptus, the Anglicized form of its scientific name *Phytoptus pyri*.

The Distribution and Past History of the Mite.—The cause of this peculiar affection of pear leaves was discovered by Scheuten, a German, in 1857; doubtless the disease itself had been observed many years previously. Later German writers, Sorauer in 1873 and 1886, Kaltenbach in 1874, and Frank in 1880 speak of the disease as common in Europe. In 1877 Murray records it as common in England and on the Continent. Crawford states that public attention was first called to the pest in South Australia in 1881. In 1891, French found it had gained a foothold in Victoria orchards. In 1888, Fletcher received specimens of the disease from Nova Scotia; and in 1891 he found it was very widespread and serious throughout Canada. These are all the references to the occurrence of the pest in other countries, that we have seen.

The first record of the appearance of the disease in the United States is in 1872 when Glover found it common in Maryland. In 1880, Burrill said the disease was widespread in this country. Osborn found the mite in large numbers on some Russian pear trees in Iowa in 1884; he thought the pest had probably been introduced with the scions of trees recently imported from Europe. In 1890, specimens were sent to Dr. Lintner from Charlotte, North Carolina with the report that the disease was very prevalent there. In 1891, we received the mites from a correspondent in Fayetteville, Ark., who said his trees were badly affected. At the meeting of the Association of Economic Entomologists in 1892, Webster of Ohio and Smith of New Jersey reported the pest as very

species. In 1851, Dujardin (An. des Sci. Nat., 3d Ser., vol. 15. p. 166) showed why he believed them to be adult forms and proposed the generic name *Phytoptus* for such four legged forms. In 1857, Scheuten, who described the Pear Leaf Blister Mite, criticized Dujardin's work and adhered to the theory that they were but immature forms. During the succeeding twenty years several observers studied the four-legged mites, and since 1877 it has been the prevailing opinion that they are adult animals forming a distinct family among the mites.

abundant in their respective States that year. This year McCarthy has found the disease very prevalent in the orchards of North Carolina.

In 1889 and 1890 the pest was abundant in pear orchards in western New York. We received specimens from Oswego in 1891; and Dr. Lintner reported it as excessively abundant in eastern New York in 1892. The disease is very common in pear orchards near Ithaca, and has very noticeably increased within the past three years. It doubtless occurs in a majority of the pear orchards in the State. This completes the recorded history of the disease in our own State and other States.

These data indicate that the disease is of European origin. It had become established in the United States in 1872 and had reached Australia in 1881, and Canada in 1888. It is widely distributed over the northern, eastern, and southern portions of the United States; and has doubtless been introduced into other sections on stock bought in the east or in Europe.

Its Destructiveness.—The destruction wrought by the mite thus far has not been very serious except in a few cases where it was excessively abundant. The infested leaves fall from the trees sooner than the others, thus depriving the tree of its breathing organs and materially weakening it. Without its leaves the tree cannot store up the necessary food in its winter buds to insure a healthy vigorous tree and a full crop the next season. The freer from disease the leaves can be kept during the summer and fall, the more vigorous will be the tree and the better will be the quality and the greater the quantity of the fruit the next season. Pear growers should therefore be on the watch for the Pear Leaf Blister and not let it get a foothold in their orchards.

The Life History of the Mite.—According to German observers, the exceedingly minute oval grayish eggs are laid by the females in the spring within the galls that they have formed, and here the young are hatched. How long they remain within the gall of their parent has not been ascertained. But sooner or later they escape through the opening in it, and seeking a healthy part of a leaf or more often crawling to the tenderer leaves of the new growth, they work their way into the tissue and new galls are thus started. In this manner the galls on a tree are often rapidly

multiplied during the summer. The mites live within the galls, feeding upon the plant cells, until the drying of the leaves in the autumn. They then leave the galls through the openings and migrate to the winter buds at or near the ends of the twigs. Here they work their way beneath the two or three outer scales of the buds where they remain during the winter. Fifteen or twenty may often be found under a single bud scale. In this position they are ready for business in the spring as soon as growth begins; and they doubtless do get to work early for their red galls are already conspicuous before the leaves get unrolled.*

The mites instinctively migrate from the leaves as soon as the latter become dry. Whenever branches were brought into the insectary, as soon as the leaves began to dry, the mites left them and gathered in great numbers in the buds. It is impossible to accurately estimate the number of mites that may live in the galls on a single leaf. Sections of galls made while in their red stage would seldom cut through more than two or three mites; but sections of the brown galls often showed four or five times as many. Thus on a badly infested leaf there is without doubt at least a thousand of the mites.

Methods of Destroying the Mites.—Owing to the fact that the mites live within the tissues of the leaves during the growing season, they are then beyond the reach of ordinary insecticides. It is obvious that they would not be affected by any poison dusted or sprayed upon the surface of the leaves. In 1890 we demonstrated that the mites could not be reached by an application of kerosene emulsion to the leaves. It was hoped that a sufficient quantity of the liquid would pass into the galls through their open mouths to injuriously affect the mites, but it did not.

Thus the only practicable method of combating the pest while in the galls is to gather the infested leaves, either by picking or pruning, and burn them. This method is a sure one, and is practicable where the pest is just starting in an orchard, or where the trees are small or when but a few large trees are attacked. It

* Mr. Crawford says: "There are two ways in which the mite survives the winter when all the leaves are shed—first, by hibernating among the hairs of and in the leaf bud, and secondly by forming colonies under the tender bark of last year's growth, as I have found them in both situations."

can be done at any time before the leaves dry and fall in the autumn, but the earlier in the season the better. In May, while the galls are red, would be the best time to do it.

The most vulnerable point at which the disease can be attacked on a large scale is when the mite is in its winter quarters in the terminal winter buds. Doubtless the pest receives a considerable check in many orchards at the annual pruning to which the trees are subjected. In this manner many of the winter buds containing the mites are removed and the burning of the brush soon after destroys the pest.

The methods just discussed are sure means and are practicable within certain limits. But a method which is cheaper, easier, more practicable, and one that is effective and applicable to large orchards, has resulted from our experiments during the last two years. One winter while experimenting to learn the effects of kerosene oil on dormant wood, it was noticed that the oil penetrated every crevice of the wood with surprising thoroughness; and it was at once suspected that kerosene might be used with effectiveness against this mite while in its winter quarters under the bud scales.

In the fall of 1891, before the leaves fell, several badly infested trees were labeled; and in February, 1892, two trees were treated with undiluted kerosene, one tree with kerosene emulsion diluted with $2\frac{1}{3}$ parts of water, and one tree was left untreated as a check.

In the spring the mites appeared in force on the check tree, but upon the treated trees not more than a dozen galls appeared during the season, the pest having thus been nearly exterminated. The trees treated with the undiluted kerosene were nearly killed, so that in this form kerosene can not be used with safety on the pear. The only apparent effect upon the trees treated with the emulsion, however, was a slight retardation in the unfolding of the leaves in the spring. This experiment was of course only an indicator, but it gave the clue. The result was not given to fruit growers at the time for it needed further verification on a larger scale, and it was desirable to know what percentage of kerosene it was necessary to apply to do the work successfully.

In September, 1892, we found sixteen quite badly infested trees.

in the Horticultural orchard here at the Station. These were then labeled, and March 10, 1893, all but two (which were left for a check) were sprayed with kerosene emulsion diluted with from 3 to 10 parts of water. The trees were standards varying from six to fifteen feet in height, but it was found that it required only about one and a half quarts of the diluted emulsion and about two minutes of time to spray a tree thoroughly from all sides with a knapsack sprayer.

July 10, 1893, the trees were examined and it was found that the four sprayed with the emulsion diluted with 3 parts of water were practically free from the disease. The four trees sprayed with the emulsion diluted five times, and the four on which the emulsion diluted with eight parts of water was used showed a very few galls, not one per cent. of the number on the trees the preceding year. Two trees which had been sprayed with the emulsion diluted with 10 parts of water showed nearly as many galls as before. The two check trees were as badly infested as they were the year before.

These results showed that the emulsion was effective when diluted with not more than 8 parts of water, or containing about eight per cent. of kerosene. The remarkable success of these experiments could be fully realized only by one who had seen the diseased trees in the fall and again a year later. To illustrate it graphically one need but imagine the four leaves shown in figure 1 (which were taken in the fall and are typical specimens of the leaves on many branches of the trees before they were treated) passed through some process by which all of the galls could be removed except one or two on each leaf; this comparison does not exaggerate the difference between the trees before and after treatment with the emulsion. In all of our work with preventive methods against insect attacks, we have never met with more striking success than we obtained by the use of the emulsion against this Pear Leaf Blister Mite.*

*Mr. Crawford doubtless first suggested the use of kerosene emulsion against this pest in winter. He said: "The habits of the mite in the winter time afford a clue to one method of treating it. For this purpose I would recommend three washes to be experimented with, viz.: Kerosene emulsion

The emulsion can be applied with equal effectiveness at any time after the leaves have fallen in autumn and before the buds have begun to swell in the spring. Dilute the emulsion† with not over 5 to 7 parts of water. Spray the tree thoroughly from every side, taking especial care to hit every terminal bud, for this is where most of the mites congregate. There is no danger of injuring the tree with this dilution of the emulsion.

In this manner the Pear Leaf Blister Mite can, we believe, be nearly exterminated in an orchard by a single thorough spraying. The method also has the great advantage of being cheap, easy to apply, and practicable on a large scale. This spraying of the tree in winter with so strong an emulsion may also destroy some of the adults of that pest most dreaded by all pear growers—the Pear Psylla—which is then in hibernation in the crevices of the bark on the trunk and large limbs; therefore spray the tree all over.

To summarize briefly, our experiments strongly indicate that

1 to 14; caustic soda, say 4, 8, and 12 ounces to the gallon; and sulphuretted lime.”

He tried no experiments and our results show that so dilute an emulsion would be of little avail. Mr. Crawford's recommendation was unknown to us until after we began to write this article.

Other authors have recommended the use of the emulsion when the mites are leaving the buds or while migrating to the buds. It would be effective if the mites could be hit at this latter time, which would, however, necessitate very careful watching with a good lens to determine the exact time to make the application. They do not leave the buds in the spring, but attack the leaves while yet in the bud; and the mites are out of reach in their galls before the leaves unroll.

† To make the emulsion, thoroughly dissolve one-half pound hard or soft soap in one gallon boiling water. While this solution is still very hot add two gallons of kerosene and quickly begin to agitate the whole mass through a syringe or force-pump, drawing the liquid into the pump and forcing it back into the dish. Continue this for five minutes or until the whole mass assumes a creamy color and consistency which will adhere to the sides of the vessel, and not glide off like oil. It may now be readily diluted with cold rain water, or the whole mass may be allowed to cool when it has a semi-solid form, not unlike loppered milk. This standard emulsion if covered and placed in a cool dark place will keep for a long time. In making a dilution from this cold emulsion, it is necessary to dissolve the amount required in three or four parts of boiling water, after which cold rain water may be added in the required quantities.

the Pear Leaf Blister can be nearly exterminated in a badly infested orchard by a single thorough spraying of the trees in winter with kerosene emulsion diluted with from 5 to 7 parts of water.

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MARK VERNON SLINGERLAND.

HORTICULTURAL DIVISION.

A NEW FOOD PLANT.—*Stachys Floridana*.*

Tuber of *Stachys Floridana*.

Two years ago, Dr. Erwin F. Smith, of Washington, sent us a curious tuber which he picked up on the sea coast in Florida. For two years an interesting progeny has been grown from this tuber, which proves to be *Stachys Floridana*, a plant not before introduced to cultivation, so far as I know. In general appearance, the plant is much like the Chorogi or *Stachys Sieboldii* which is sold as an esculent by the seedsman, and a detailed report of which was made from this station two years ago;† It differs from the Chorogi, amongst other things, in its more slender habit, smoothness, and its long-stalked cordate leaves. The tubers are produced as freely as in that species and are generally somewhat larger. The illustration shown herewith is a life-size picture of the greater portion of a tuber, which, however, was rather above the average size. The tubers commonly reach the length of four to six inches, and the joints are of nearly uniform thickness. The flavor is fully equal to the Chorogi, and we sometimes think it better, being perhaps, somewhat more crisp and brittle. The plant has not yet been grown in the open ground, but we now have sufficient stock to make the experiment the coming season. I expect that the plant

**Stachys Floridana*, Shuttleworth, MSS.; Bentham, D. C. Prodr. xii. 478 (1848).

† Bulletin 37, p. 394.

will be able to endure our winters with the protection of a mulch, for tubers that have been frozen grow readily. There is every prospect that this interesting species will add another attractive vegetable to our gardens.

Stachys Floridana is known to occur only in eastern Florida, and it is one of the comparatively little known plants of the genus. Chapman, in his Flora of the Southern United States, calls it an annual, but Gray describes it as producing "a moniliform tuber of two or three inches in length."

Gray says that the plant is "barely a foot high" but under cultivation it grows to the height of two feet.



Stachys Floridana. ($\frac{1}{2}$ natural size.)

THE MOLE-PLANT.—*Euphorbia Lathyris*.*

The horticultural community was interested last spring in the announcement of Samuel Wilson, of Mechanicsville, Penn., that he had a plant which will drive moles from the garden. This plant, although said to be biennial, was called the Mole-Tree, and the account was verified by the picture, which shows a diminutive tree beneath which lies the corpse of a mole. Nothing is said by the introducer about the origin, nativity or botanical affinities of the plant. We were able to secure but one plant of the Mole-Tree, and we were so choice of it that it has been grown in the greenhouse. It turns out to be an interesting old garden plant, which has a continuous history of at least three hundred years, and which was known as a medicinal plant to Galen in the second century. It is the Caper Spurge, *Euphorbia Lathyris*. The name Spurge is applied to many related plants, in reference to their purgative qualities, and this particular species is called Caper Spurge from the fact that the little seed-like fruits are sometimes used as a substitute for capers. The plant is known chiefly as a household medicine, although it is used in *materia medica* and is figured by Millspaugh in his recent work upon American Medicinal Plants. Its use as a food plant seems, fortunately, to have ceased. Johnson, in Sowerby's *Useful Plants of Great Britain*, 1862, speaks of this use of it as follows: "The three-celled capsules are about the size of a large caper, and are often used as a substitute for that condiment, but are extremely acrid, and not fit to eat till they have been long macerated in salt and water and afterwards in vinegar; indeed it may be doubted whether they are wholesome even in that state."

This plant is a native of Europe, but it has long been an inhabitant of old gardens in this country, and it has run wild in some of the eastern states. Its use as a mole repeller is not recent. Pursh, in writing of the plant in 1814, in his *Flora of North America*, says that "It is generally known in America by the name of Mole-plant, it being supposed that no moles disturb the ground where this plant grows." Darlington makes a sim-

* *Euphorbia Lathyris*, Linnæus, Sp. Pl. 655 (1753).



A Young Mole-plant, end view.

ilar statement in *Flora Cestrica*, 1837: "This foreigner has become naturalized about many gardens,—having been introduced under a notion that it protected them from the incursions of moles." In later botanies it is frequently called Mole-plant. I do not know if there is any foundation for these repeated statements that the Caper Spurge is objectionable to moles, but the fact that the notion is old and widespread raises a presumption that the plant may possess such attributes. This statement

occurs only in American works, so far as I know. It would be interesting to know the experiences of those who have grown the plant for a number of years, for the subject is worth investigation. But we cannot too strongly deprecate the practice of introducing plants to the public without giving purchasers definite knowledge of their history and nature, and without having detailed proof that the plants possess the virtues which are claimed for them. It would have been better in the present example, no doubt, to have submitted the plant to a botanist before introducing it, in order that its proper name and history might have been determined; and if the public is at all inclined to buy a mole-plant it would have been persuaded much more by the long tradition of its virtues than by any consequential statement of its value.

The Caper Spurge is apparently biennial, although Boissier, a celebrated monographer of the euphorbias, calls it annual. The plant is very unlike in its early and flowering stages. Until it begins to branch and flower, the leaves are long linear-lanceolate, opposite, and arranged in four perfect rows down the thick, smooth stem. As this stage of the plant is rarely illustrated or described, I have introduced here a photograph of our Mole-plant as it appeared eight months after its receipt from Mr. Wilson. It was placed horizontally and an end view was taken in order to show the serial arrangement of leaves. The plant is exceedingly curious and interesting, and we shall grow it in our greenhouses as an ornamental subject. Few plants have a more novel or striking appearance. In its second or flowering stage, the leaves are ovate and shorter. Mr. Wilson writes me that he knew this plant in old gardens more than fifty years ago, where it had a reputation for expelling moles, but he lost sight of it until a short time since, when he again met with the plant. It was then propagated and introduced to the public.

ORCHARD COVERS.

A year ago* a report was made upon the use of the European vetch (*Vicia sativa*) as a plant for growing in orchards,—to afford

*The Vetch or Tare as an Orchard Plant, Bull. 49, Cornell Exp. Sta. 354.

a cover for the soil in late summer, fall and winter, and to provide fertilizer when plowed under the following spring. Observations have been continued upon the vetch this year, and experiments have been tried with common field peas, cowpeas, and other plants, as covers for orchard lands.

The vetch is an annual leguminous plant which continues its growth long after frost and which mats down with the snow into a perfect, carpet-like covering. In the spring, the vines are so well decayed that the cover can be plowed under easily. The vetch can be sown late in June or early in July in this State, and the plants will cover the ground with a dense tangled mulch two feet deep when winter sets in. Last year (1892), we sowed the vetch June 16. This year we sowed one area June 20, and another June 28. Both made an ideal mulch, and the plants were green and still growing late in November. They produced no seeds, and but very few flowers. About a bushel of seed should be sown to the acre. The seed is large and germinates readily, and is likely to catch at almost any time during the summer. Some idea of the dense growth of the vetch this year may be obtained when I say that one patch overcame and obscured a heavy growth of horse radish which had been in the ground two years. I am confident that upon fairly good soil, good results can be obtained with vetch sown as late as the middle and possibly the last of July. We have obtained our seed from J. M. Thorburn & Co., of New York, who sell it for \$3.50 per bushel. Other dealers probably keep it. An analysis of the vetch, as given in our report for last year, and repeated below, shows that it is rich in fertilizer value.

There has been considerable inquiry concerning the value of cow peas for northern orchards. Sixteen varieties were grown at the Station this year for the purpose of ascertaining which ones will mature in this latitude; and over half an acre was sown to the Black pea, which Professor Massey, of North Carolina, thought likely to prove the best variety for our purpose. These black peas were obtained of L. R. Wyatt, Raleigh, N. C., and were sown June 20. The land was clay and variable in contour, comprising two dryish knolls, with a moist vale lying between them. The peas were slow in starting, owing to the hard soil, but they made

a fair growth in August and early September. In the vale, the plants grew nearly two feet high and covered the ground well, but on the knolls the soil was not covered. The plants had just begun to flower when they were killed by the first frost. The leaves fell off, and the bare stiff stems now afford very little protection to the soil.

The varieties of cow peas grown for the purpose of ascertaining the earliness of the various kinds, were sown May 31 in rich garden loam. These peas were obtained from the experiment stations of North Carolina, Arkansas and Louisiana. The varieties ripening seeds are ten, as follows:

- Black, from N. C.
- Black Eye, N. C.
- Blue, La.
- California Bird's Eye, Ark.
- Clay, N. C.
- Gray Prolific, N. C.
- Large White, La.
- Whipporwill, N. C., Ark., La.
- Yellow Prolific, N. C.
- Yellow Sugar Chowder, Ark.

The varieties which did not mature seeds are the following:

- Black, from La.
- Brown Eye, Ark.
- Clay, La.
- Conch, N. C.
- Indian, La.
- King, La.
- Lady, La.
- Purple Hull, La.
- Stewart, N. C.

The varieties which seemed best adapted to this latitude were the Black and Whipporwill. The latter I fruited also at Lansing, Michigan, in 1887. It will be seen that there appears to be a difference between samples of the same variety coming from different sources. The Black pea from North Carolina seed matured well, but that from Louisiana stock was too late. The same difference occurred in the Clay. This is what might have been expected,

and it emphasizes the importance of securing seed from the northernmost station, when choosing stock for growing in the north. On the whole, the Black cow pea seems best adapted to growing in Central New York. A small patch of this was sown on a rich, loose soil July 17, and the plants made as heavy growth as those sown upon the clay soil nearly a month earlier. But the cow pea affords so much less winter protection to the soil than the vetch, without any counterbalancing advantages, that it can scarcely be recommended for an orchard cover in the north.

The ordinary field pea was also grown this year as a winter cover. One lot was sown August 18. Although the tips of the plants were somewhat shriveled by frost, the plot was still green and growing the middle of November, but no flowers had appeared. The vines were two to three feet long and they covered the ground completely, and made an excellent mulch. Peas sown September 20 reached a height of about six inches and were not large enough to afford a satisfactory cover; yet, if sown very thick, peas could be put in at this time with fair result, in cases where the ground could not be used earlier.

Aside from these covers, various kinds of clovers were sown in mid-season for purposes of comparison, but they made a poor stand and afforded very little protection to the soil. Rye sown late in August or early September made a fair cover, but it is no better than common field peas, if as good, and its fertilizing value is small.

The following analyses show the fertilizer values of the various plants here discussed. The vetches and peas were analyzed at this Station. The analysis of cow peas is taken from Professor Teller's recent studies in Arkansas,* and that of clover is compiled from reliable sources for comparison.

	Original substance.	Dry substance.
<i>Vetch, ready to bloom, roots and tops.</i>		
Nitrogen.	.65 per cent.	3.10 per cent.
Phosphoric acid	.146 "	.70 "
Potash	.475 "	2.28 "
Water	.79.15	

* Bull. 24, Ark. Exp. Sta. July, 1893.

Peas, 2 to 3 ft. high, no flowers, roots and tops.

Nitrogen	.451	"	2.33	"
Phosphoric acid.....	.113	"	.58	"
Potash	.361	"	1.86	"
Water.....	80 61	"		

Peas, 6 in. high, roots and tops.

Nitrogen	.34	"	2.43	"
Phosphoric acid.....	.086	"	.62	"
Potash	.179	"	1.28	"
Water.....	86 05	"		

Cow peas (Whipporwill), in blossom, straw only.

Nitrogen	3.09	"		
Phosphoric acid.....	.50	"		
Potash	1.98	"		

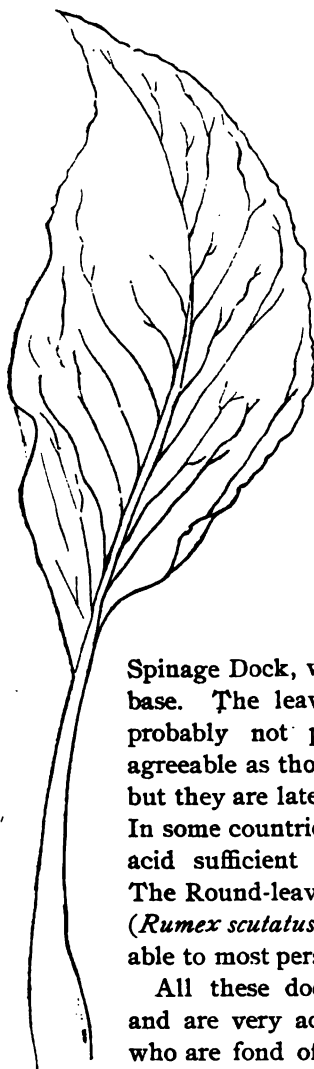
Red Clover, average of several analyses.

Nitrogen	2.05	"		
Phosphoric acid.....	.66	"		
Potash	2.24	"		

It will be seen that the vetch ranks highest in fertilizer value, although it is not greatly above cow peas. But cow peas afford little protection to the soil during winter and can therefore scarcely be recommended for an orchard cover in this latitude. Next to the vetch in value is the common field pea, and as it affords a good cover when sown as late as the middle or last of August, it may often be more useful than any other plant.

GARDEN DOCKS.

Various species of docks and sorrels have long been cultivated as pot-herbs. Some of them are very desirable additions to the garden because they yield a pleasant food very early in spring, and, once planted, they remain for years. We have grown two of the French docks for years and find them to be very good. One is the Spinage Dock (*Oseille Epinard*), the other the Large Belleville (*Oseille Large de Belleville*). The former is the better of the two, perhaps, and it has the advantage of being a week or ten days earlier. The broad crisp leaves appear early in April when there is nothing green to be had in the open garden, and they can be cut continuously for a month or more. This dock is the Herb Patience, or *Rumex Patientia* of the botanies. It has long been an inhabitant of gardens, and it has sparingly run wild in

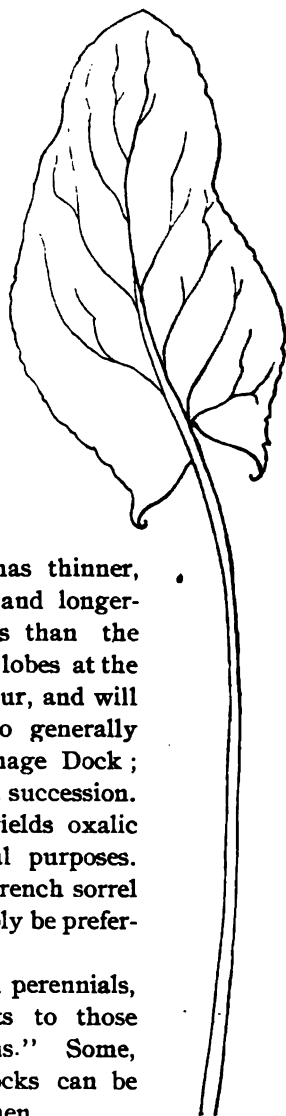


*Spinage
Dock.*

some parts of this country. It is a native of Europe. The Belleville is also a European plant, and is really a sorrel. It is *Rumex Acetosella* of botanists. It has also become spontaneous in some of the eastern portions of the country. It has thinner, lighter green and longer-stalked leaves than the

Spinage Dock, with spear-like lobes at the base. The leaves are very sour, and will probably not prove to be so generally agreeable as those of the Spinage Dock; but they are later, and afford a succession. In some countries this sorrel yields oxalic acid sufficient for commercial purposes. The Round-leaved or true French sorrel (*Rumex scutatus*) would probably be preferable to most persons.

All these docks are hardy perennials, and are very acceptable plants to those who are fond of early "greens." Some, at least, of the cultivated docks can be procured of American seedsmen.



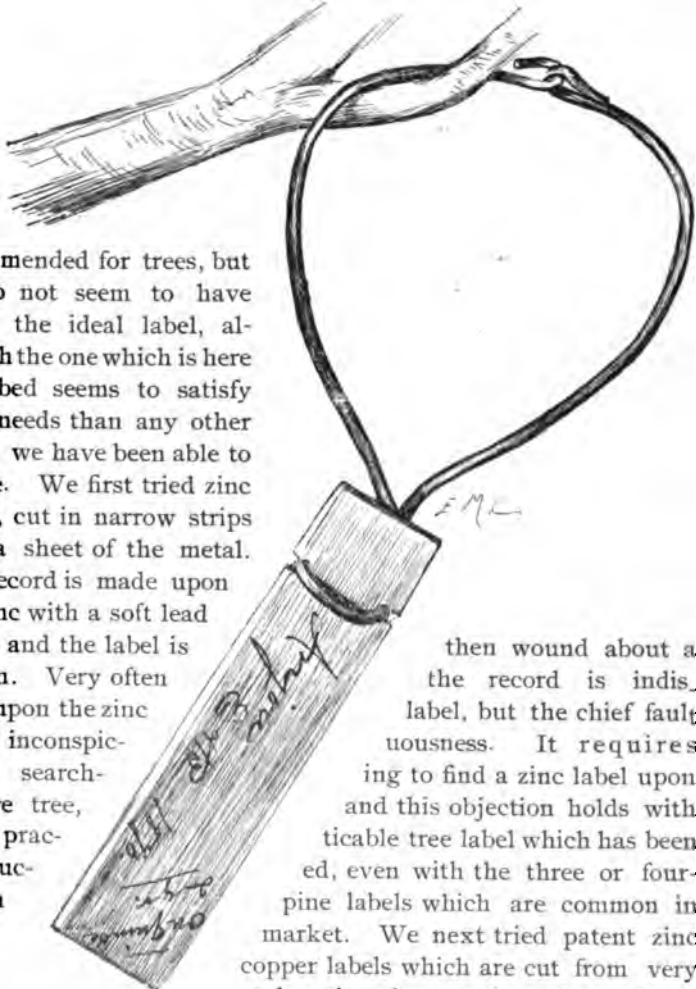
*Belleville
Dock or
Sorrel.*

LABELS.

Anyone who has had experience in gardens knows that the methods of labelling plants and trees are nearly always unsatisfactory in some particular. A great variety of labels has been

recommended for trees, but we do not seem to have found the ideal label, although the one which is here described seems to satisfy more needs than any other which we have been able to secure. We first tried zinc labels, cut in narrow strips from a sheet of the metal. The record is made upon the zinc with a soft lead pencil and the label is tinct upon the zinc is its inconspic- much search- a large tree, every prac- introduc- inch the and thin

The Cornell Tree Label.



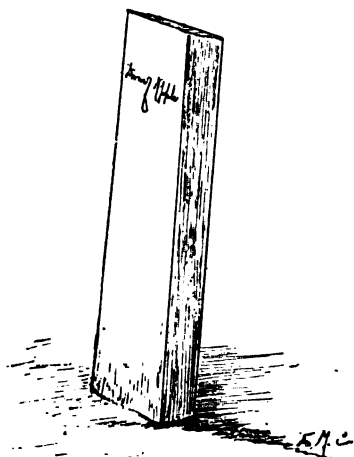
then wound about a the record is indis- label, but the chief fault- ousness. It requires ing to find a zinc label upon and this objection holds with ticable tree label which has been ed, even with the three or four- pine labels which are common in market. We next tried patent zinc copper labels which are cut from very metal so that the record can be made by

the impression of a sharp point or style. These pretty and so-called indestructible labels are furnished with an eyelet through which the wire passes. We were much pleased with these labels when we put them upon our orchard trees one fall; but the next spring we found that the metal had broken away from the eyelets and nothing remained of them but a hole hung upon a wire.

We now label our trees with the device shown in the illustration. We buy the pine "package label" which is used by nurserymen, and which is 6 in. long and $1\frac{1}{4}$ in. wide. These labels cost, painted, \$1.30 per thousand. These are wired with stiff, heavy galvanized wire, much like that used for pail bales and not less than eighteen inches is used upon each label. Hooks are turned in the ends of the wires before the labels are taken to the field. A pail of pure white lead, well thinned with oil, is taken to the field with the labels. The record is made with a very soft pencil, the label is dipped into the paint, the wire is placed about a conspicuous limb and the hooks are joined with a pair of pliers. The paint at first almost completely obscures the writing, but some of it drips off and the remainder dries in, so that the record becomes bright and the soft pencil marks are indelibly preserved, while the label remains white. If the paint is brushed on, the soft writing will be blurred. If in the future the wood becomes gray, the label can be brightened by immersing it in a pot of white lead, without removing it from the tree. The large loop of wire allows of the growth of the branch and the label hangs so low that it can be seen at a glance. The heavy, stiff wire insures the safety of the label against boys and workmen. It cannot be removed without a pair of pincers. The label is large enough to allow of a complete record of the name of the variety, the place of purchase, age, and other matters; and it is readily found.

For temporary or annual plants, where little horse work is done, we like the commercial garden stakes, $12 \times 1\frac{1}{4}$ in. These cost us, when painted and made of soft clear pine, \$4.55 per thousand. For more permanent stake labels, we use the one shown in the picture, and which is sawed at the nearest mill. This is cut from clear pine and is 2 ft. long, $3\frac{1}{2}$ in. wide, $1\frac{1}{2}$ in. thick, and sawed to a point. These are given two thin coats of white lead, care being taken not to pile them upon their faces until thoroughly

dry, to avoid a rough surface for the pencil. The record may be made by a large soft pencil, like a carpenter's pencil, or by a brush and black paint; but for all annual crops the pencil will be



A good Stake Label.
(24 x 3½ x 1½ in.)

found more serviceable. At the end of the season or when the record becomes dim, a thin shaving is planed off the face of the label, it is repainted, and used again. We gather up these labels from the vegetable garden each fall and dress them up during winter. The label is thick enough to allow of many annual dressings, while the lower portion is not reduced and it therefore lasts for many years and is strong enough to resist the shocks of cultivator or whippetrees. For ornamental bushes this large label is too conspicuous, and for this

purpose we use a pine label 1½ in. wide, ½ in. thick, and 18 or 20 in. long, and the lower half is soaked in a strong solution of sulphate of iron (copperas), and, after drying in lime water, to preserve it.

RECENT VARIETIES OF TOMATOES.

The year 1893 was prolific in new tomatoes. It is impossible to make an extended report upon the tomato experiments of the year at this time, but the following brief running notes of the newer varieties may be of value :

Aristocrat Dwarf (Livingston). Habit of Dwarf Champion. Fruits red, small but very even and uniform and round, solid, and attractive. Apparently a valuable amateur variety.

Baltimore Prize Taker (Landreth). A purple tomato of medium size, round and smooth. Attractive, but seemed to possess no superior merits.

Buckeye State (Livingston). A very large and productive round, heavy, purple smooth tomato. Seems to be the best novelty

of the year on our grounds, and apparently worthy of general use.

Comrade (Gregory). A small and round early tomato, red, like Prelude in shape, valuable for its earliness, although here it did not equal Advance in this respect.

Early Michigan, or *Early Red Apple* (Ferry). Red, of medium size, round and regular. A good, handsome variety, but scarcely large enough to compete with other tomatoes in the general crop. It was not very early here.

Earliest of all (Salzer). A red, angled tomato of medium size, with a tendency to be flattened. It was not early here, and it seemed to have no striking qualities.

Extra Early Advance (Burpee). Our earliest tomato this year. A small red tomato of uniform size and shape, not very far removed from the Cherry type. Valuable only on account of its earliness.

Gold Ball (Livingston). Much like the old White Apple, except a little longer and of a bright lemon color. Early.

Hubbard's Early (Jerrard). A curled-leaved variety of the old angular type, red, appearing to be identical with the old Hubbard's Curled Leaf.

La Crosse Seedling (Salzer). Mixed, part of the plants like Dwarf Champion, and others slender growers with red angular fruits. Of no value with us.

Lemon Blush (Thorburn). Fruit of medium size, bright lemon with a faint blush, early. A good variety, and apparently worth general dissemination.

Logan's Giant (Everitt). An irregular, very late tomato, of no value here.

May's Favorite (R. D. Hawley, & Co., Hartford, Conn.). A medium red tomato, uniform, regular and good. Seems promising.

Salzer's First Prize (Salzer). A flattish red variety of medium size, and apparently valuable for home use.

Salzer's Giant Tree (Salzer). Much mixed. Most of the plants bore a smallish red tomato with no pronounced attributes.

Salzer's Morning Star (Salzer). We could not distinguish it from Mikado.

Salzer's New Pot (Salzer). Mixed. Mostly like Dwarf Champion.

Semperfructifera (Pitcher and Manda). A red tomato of the

Plum type, but somewhat angular or cornered in form. It was not early with us. One plant bore a large round fruit and was evidently a "rogue." Valuable only for domestic use.

Shenandoah (May). Large red flattish tomato of uniform size and regular. Very promising.

Storm King (Buckbee). Seems to be indistinguishable from small forms of the old White Apple.

Ten Ton (Landreth). Fruits medium to small, red, apparently not valuable here.

Terra Cotta (Thorburn). A medium to large buff-red regular tomato, of novel color. Interesting, and apparently valuable.

Topound (Huntingdon). Very much like *Shenandoah*. Good.

World's Fair (L. H. Reed, Grand Rapids, Wis.). A red flattish tomato with small foliage, and evidently an offshoot of the old angular or cornered type of tomatoes. It seems to have no particular merits here.

TOMATO-POTATO GRAFTS.

Frequent statements go the rounds of the press describing some mysterious or extravagant results which have been obtained by intergrafting tomatoes and potatoes; and one correspondent has reached the point of naming his mongrel the "Potomato," and from it he expects to reap compound crops of tomatoes and potatoes. The truth is that the grafting of the tomato on the potato, and *vice versa*, is no new thing; and it is equally well known that no economic results come from the union. Yet the subject is an interesting one to those who are curious concerning the habits of plants, and it is true that potato tubers will grow without potato tops and tomato fruits will ripen without tomato roots. In order to set the matter right, it has seemed best to make a report of some of these grafts which we made three years ago, although a brief account of them has already been published.*

The grafts comprised tomatoes on potatoes and potatoes on tomatoes. Plants for the purpose were grown in pots, and the grafting was done in the greenhouse when the plants were but a few inches high.†

* Carman, *The New Potato Culture*, 151.

† For an account of the methods of grafting herbs, see Bull. 25, Cornell Exp. Sta. 175.



Potato-on-tomato plant.

All sprouts were promptly removed from the stock below the union, and when the plants were set out of doors the parts were strongly knit together. Nevertheless, it was necessary to set the plants in a protected place to avoid injury from winds. The illustrations show a representative plant from each lot. It will be

seen that the tomato-on-potato plant bears a handful of tubers, together with a fair crop of tomatoes. The products of the two parts looked to be perfectly normal, although the potatoes did



Tomato-on-potato plant. Tomatoes above; potatoes below.

not grow when planted, and the tomatoes seemed to develop the full tomato flavor. In this case, there was not a potato leaf allowed to develop the entire season. The potatoes were manufactured by tomato foliage. But the plant which bore

the best crop of tomatoes bore no tubers on the potato roots—the strength seemed to have gone entirely into the tomato top.

The potato-on-tomato plants were infertile; that is, the tomato roots had no tubers and the potato tops, while they bloomed freely, produced no balls. The failure of the potato top to produce balls is probably not due to the fact that it had a tomato root, however, for comparatively few modern varieties of potatoes go to seed, even if they flower freely. There are records of potato tops on tomato roots having produced potato-like tubers in the axils of the leaves, and this curious circumstance has been thought to indicate a sort of graft-hybridism between the potato and tomato. I am ready to believe that such tubers have been produced, but they occasionally appear upon normal potato plants, and we have frequently produced them when propagating potatoes from cuttings of the growing shoots. Auxillary aerial tubers, while rare, are perfectly well known, and it would not be strange if, when the plant is prevented from making tubers in the ground, it should spend its energy elsewhere.

But however interesting these experiments may be to the plant physiologist, it is well for the reader to know that there is nothing mysterious in the operation of grafting the plants, and that there is no likelihood that any economic results will follow.

HARDY CARNATIONS.

There is comparatively little known in this country about hardy, or what the English call border carnations. The energy of American carnation growers has been directed almost entirely to the winter or house type. This winter or forcing type is a modern evolution from the hardy carnation, and there seems to be no reason why the two types should not succeed equally well in this country. Gardeners of foreign birth usually dismiss the hardy carnations by saying that our climate is too hot and dry for them. While there may be much truth in this position, it is also true that many and perhaps all of the border varieties can be grown here with little trouble. Some persons have grown them with perfect satisfaction for years, and visitors to the World's Fair in early August must have noticed a glowing bed of them upon the wooded island.

In order to determine if these plants can be successfully grown with only ordinary care, such as any person can give, we secured seeds, in the spring of 1892, of the following strains: Early Margaret, Self Colored, Early Dwarf Mixed Vienna, Red Grenadine, Splendid Rose-leaved, Picotee, and some others. These were sown in boxes in the greenhouse on the 8th of March, but they might just as well have been sown out of doors when the season opened. The plants were set in the field as the season advanced. A few of them bloomed in the fall. They were allowed to go through the winter wholly unprotected, although they grew upon bald hill-top; and the last winter was severe at Ithaca. They all wintered well, and they began to bloom about the middle of June and gave an uninterrupted display of bright colored and interesting forms until late in August. Although the lot was a



Border Carnations. — The Vienna.

mixed one, having come from seeds, all the varieties were interesting, particularly the single flowers. If any one strain were more pleasing than another, it was probably the Vienna, which bore single and semi-double little flowers of very pure and dainty colors, ranging from ivory-white to rose-red. Some of the plants had been taken up in the fall and removed to the house for winter bloom, and here, too, the Vienna was very pleasing. These hardy carnations will live on from year to year, although so good results cannot be expected from the subsequent seasons of bloom, and it is best to raise new plants from seeds.

SHED FOR STRATIFIED SEEDS.

Seeds of fruits and nuts and many hardy herbs usually germinate best when placed in moist soil and subjected to frost. It is



A Handy Seed Shed.

the practice of gardeners to place such seeds in boxes between layers of sand, and to expose them to the weather. Such seeds are said to be stratified. If more than one layer of seeds is placed

in the box it is with the intention that they shall be sifted out the next spring and sown ; but for all small parcels of seeds, such as usually fall to the lot of the experimenter, it is better to sow them regularly in boxes, and then expose them during winter, allowing them to germinate without re-sowing. Some hard seeds will not germinate under two years, and occasionally they require even more time ; but the boxes are kept clear of weeds, and the gardener abides his time.

With experimenters and others who have choice and often hybridized seeds to grow, it is a serious question what to do with these boxes of seeds, and how to keep a record of them. If kept in a building, they become too dry during winter, or if the seeds grow, the young plants are likely to die for want of light. If put out of doors, shade must be provided to keep the boxes moist and to prevent the young plants from becoming scorched by the sun ; and the boxes are likely to get upset, the labels broken off or blown out, or the rains may wash out the seeds. We have been in the habit of placing these boxes under trees, where they make a convenient sitting place for workmen, and the labels afford entertaining whittling ; and, more than all, the birds drop seeds into the boxes and destroy the value of experiments. We were much delighted with curious results which we got from boxes of hybridized raspberry and blackberry seeds ; but when one raspberry box came up to strawberries we began to think that someone or something had taken an interest in our investigations.

But we are no longer troubled. The picture shows the shed in which we keep our stratified seeds, under lock and key. We call it a Seminarium. The roof is tight, but the sides are covered only with galvanized wire netting. The meshes in this netting are never more than a half inch, so that mice are excluded. The rains and snows beat into the place, and when the seeds germinate, the plantlets find light enough for their purpose. A record-book goes with this Seminarium, with columns for the entry of the following items : Name of sample ; where from ; date of sowing ; number of box or pot ; by whom sown ; when transplanted ; permanent quarters. The house is used also for the storing of cuttings, which are planted in boxes, the same as seeds. Such quarters are indispensable to any institution where many

seeds of hardy plants are sown, and especially where experimental injury is attempted.

WHITEWASHING WITH THE SPRAYING PUMP.

The use of Bordeaux mixture in the spraying pump suggests that the machine can be used to good purpose in spraying whitewash upon greenhouse roofs, barn basements and fences. We now apply all the whitewash upon our larger glass roofs by means of a pump and nozzle. The whitewash is made in the ordinary manner, of lime and water, and is diluted to about the consistency of thin cream. If a large surface is to be covered, especially if it is difficult to reach, a direct delivery nozzle, like the Boss or a common discharge nozzle, is used, and the operator stands several feet away. But if it is desired to cover the surface evenly and neatly, the Mc Gowen nozzle is most satisfactory.

A POTATO PRESERVER.

Last spring a prominent seedsman sent us samples of potatoes, cut for planting, in very small pieces, and thickly coated with a white powder. These tubers were obtained from a dealer in potato novelties in the West, who said that he had discovered a material which would prevent the pieces of tuber from shrivelling, thus allowing the seedsman to cut away most of the flesh of the tuber and to send the lightest possible bulk through the mails. A chemical examination of the material, however, showed it to be only ordinary land-plaster (calcium sulphate). Farmers often dust plaster over freshly cut seed-potatoes for the purpose of absorbing the moisture and rendering the tubers easier to handle; and it is possible that the coating of plaster, when it dries upon the tuber, may prevent the loss of moisture and delay shrivelling, but its advantage in this respect must be small.

L. H. BAILEY.

